OF THE AMERICAN WELDING SOCIETY PUBLISHED FOR THE ADVANCEMENT OF THE ART OF WELDING

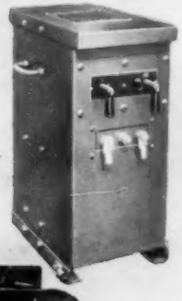
The Welding Journal

VOLUME 16 JULY 1937 NUMBER 7

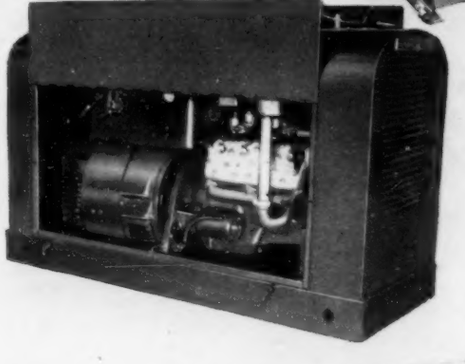
MAXIMUM PROFITS RESULT ONLY WHEN THE RIGHT TYPE OF EQUIPMENT IS USED

Low-current d-c welder

Electric-motor-driven d-c welder



Low-current a-c welder



Gas-engine-driven d-c welder

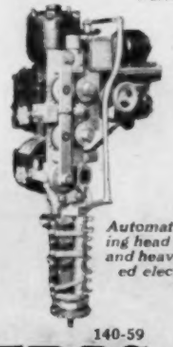
Typical a-c welder, 1000-amp and smaller

MAXIMUM returns from fabrication and repair work are obtained by users who make doubly sure that their equipment is selected to suit the job. Some savings, of course, can usually be shown with almost any type of arc welder — but *maximum profits* result only when the *right* type is used.

General Electric manufactures the largest variety of arc-welding equipment on the market, thus making it possible for it to supply *any* customer with the *right* type. The costly necessity of compromise selection is avoided. Some of the popular types of G-E welders are illustrated here. No other manufacturer offers such a wide choice.

Are you getting maximum returns from your fabrication and repair work? Your nearest G-E arc-welding distributor or G-E sales office will be glad to assist you in the selection of the type of equipment you need. General Electric, Schenectady, N. Y.

Atomic-hydrogen welder



Automatic welding head for bare and heavily coated electrodes

140-59

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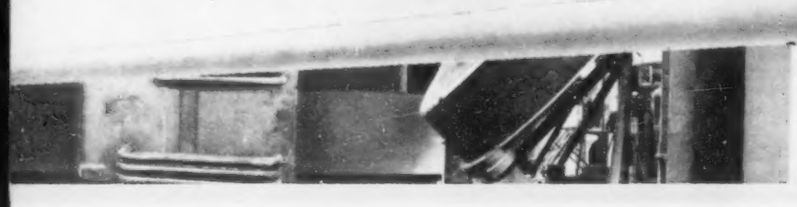

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CONTENTS

Technical Papers, Items and Reports Page

Keeping Cool with Welding . . . 2
The Golden Gate Bridge Is Completed, by *E. L. Mathy* . . . 4
Shipyard Installation, by *Ira B. Yates* . . . 7
Welded Steel in High Speed Railroad Service, by *Everett Chapman* . . . 8
Light-Load Steel Framing for Residences, by *George C. Routh* . . . 13
Tentative Rules for the Qualification of Welding Processes and Testing of Welding Operators . . . 15
Design of Connections, by *H. C. Whittlesey* . . . 17
Some Effects of Welding on Ship Construction, by *James B. Hunter* . . . 23
Time Control Solves Spot Welding Problems, by *H. Thomasson* . . . 26
Carbon Arc Welding in Marine Construction, by *Frank Hirner* . . . 27
Approved Method for Repairing Furnace Crowns, by *H. C. Shepheard* . . . 27
Welding in the Construction of Building Piping Services, by *A. S. McCawley* . . . 28
Current Welding Literature . . . 30
Index to Advertisers . . . 31

Society and Related Activities

A Message from Our President . . 32
Philip G. Lang, Jr. . . . 32
New Sections in the Making, by *Warner S. Hays* . . . 33
San Joaquin Valley Section Under Way . . . 34
Business to Be Combined with Pleasure at Summer Session of A. I. E. E. . . . 34
Iron and Steel Engineers Meeting . 34
Oklahoma City Section in the Making . . . 34
Resistance Welding Data . . . 35
Lincoln Arc Welding Prizes . . . 35
Minneapolis Chapter Being Formed . . . 35
Membership Growth . . . 35
Steel Sheets . . . 36
New A. S. T. M. President . . . 36
Birmingham on the Way . . . 36
Welding at the Railroad Exhibit . . 36
Section Activities . . . 36
Come to Atlantic City and Meet the Welding Folks . . . 37
Tentative Program, 18th Annual Meeting, A. W. S. . . . 38

Research Supplement

Published Reports . . . 1
Personnel Welding Research Committee . . . 1
Literature Reviews Favorably Received . . . 3
Electric Arc Welding of Monel Metal Structures, by *James F. Maguire* . . . 4
Loss of Material in Flash Welding and Automatic Flash Welders, by *E. Rietsch* . . . 7
An Investigation of Plug and Slot Welds, by *Glenn James Gibson* . . . 10
Peening and Its Effects on Arc Welds, by *E. M. MacCutcheon, Jr.*, and *D. M. Kingsley, Jr.* . . . 22
Shrinkage Distortion in Welding—A Review of the Literature to Jan. 1, 1937, by *W. Spraragen* and *G. E. Claussen* . . . 29
Welding Aluminum and Its Alloys . . . 39

ISSUED MONTHLY

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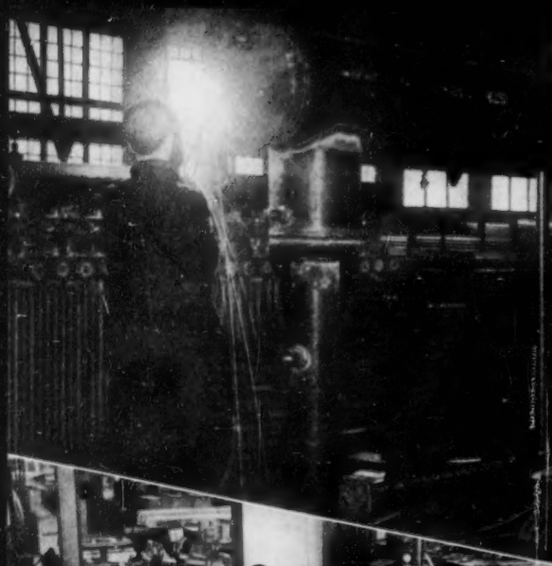
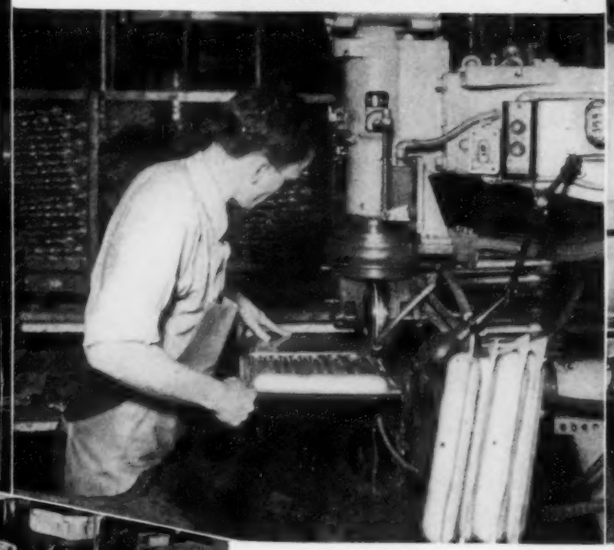
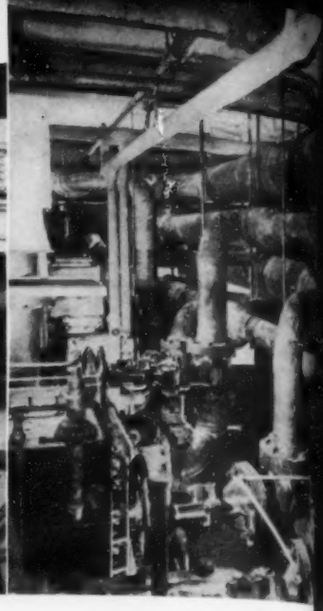
Left—Welding Brine Tank Coil—Courtesy Vilter Mfg. Co. Below—Stainless-Steel Evaporator Being Resistance Welded for General Electric Refrigerating Machine. Right—Welded Lines from Ice Machines and Circulating Pumps. Courtesy Air Reduction Sales Co.



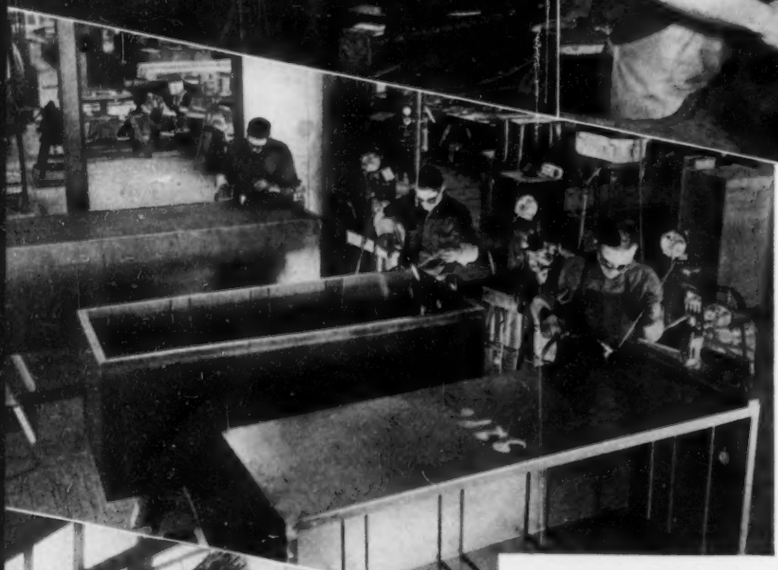




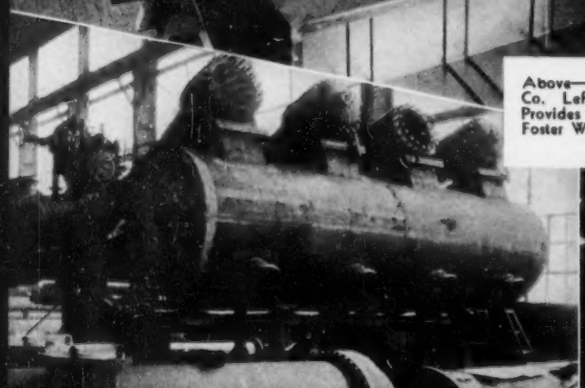
KEEPING COOL WIT

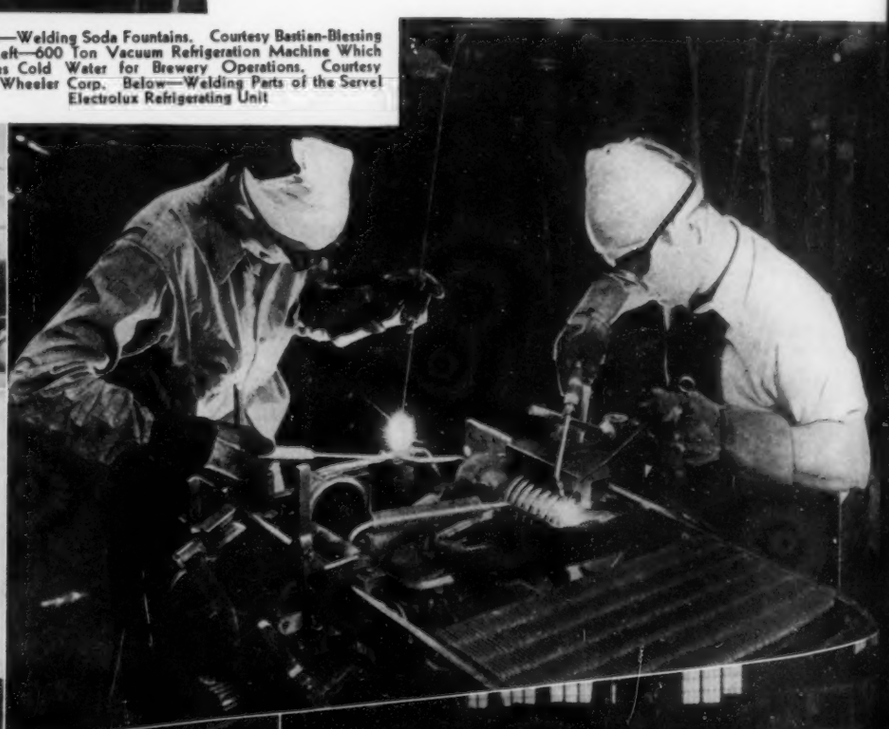
In the Industries That Help Us Keep Co Welding Method Because of Its Flexibility, Ec ny, Supe

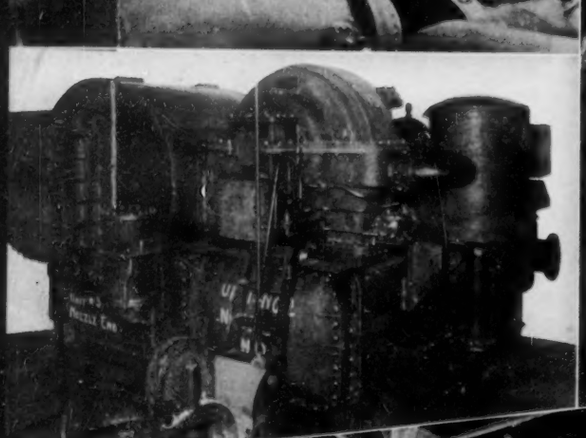
ONE of today joints uipment. pensive re e no warn a charge Welding ting great Fast freezi ation. In s 60 with withstood ded joint Welding is ustries. T a welded The popul sure to e of the var



Above—Welding Soda Fountains. Courtesy Bastian-Blessing Co. Left—600 Ton Vacuum Refrigeration Machine Which Provides Cold Water for Brewery Operations. Courtesy Foster Wheeler Corp. Below—Welding Parts of the Servel Electrolux Refrigerating Unit

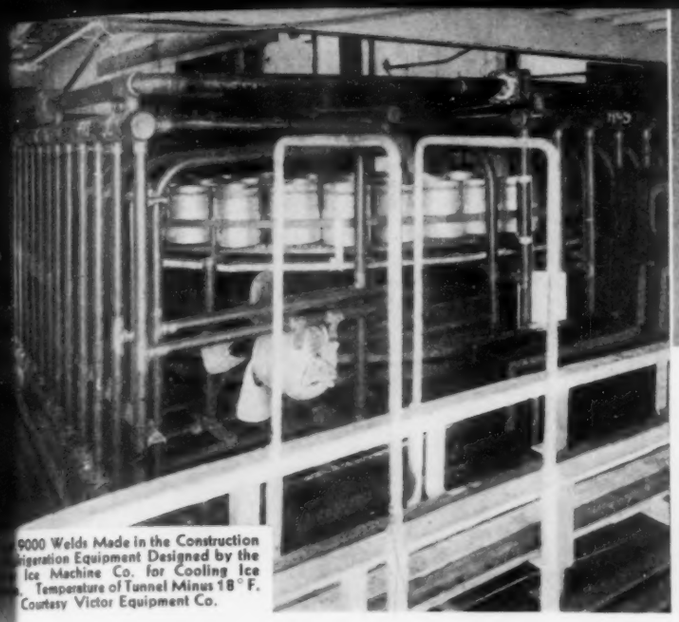






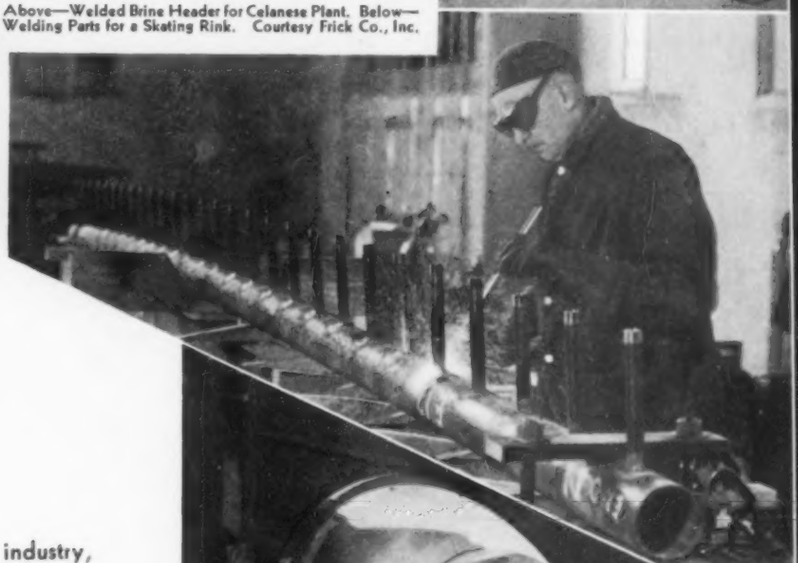
Above—Carrier Centrifugal Refrigeration Compressor Being Assembled for Air Conditioning Gold Mine in South Africa

Left—Welded Ammonia Evaporator Unit for an Ice Tank. Courtesy Lincoln Electric Co. Above—Ammonia Condenser Head. Courtesy Harnischfeger Corp.



9000 Welds Made in the Construction
rigeration Equipment Designed by the
Ice Machine Co. for Cooling Ice
. Temperature of Tunnel Minus 18° F.
Courtesy Victor Equipment Co.

Above—Welded Brine Header for Celanese Plant. Below—
Welding Parts for a Skating Rink. Courtesy Frick Co., Inc.



L WITH WELDING

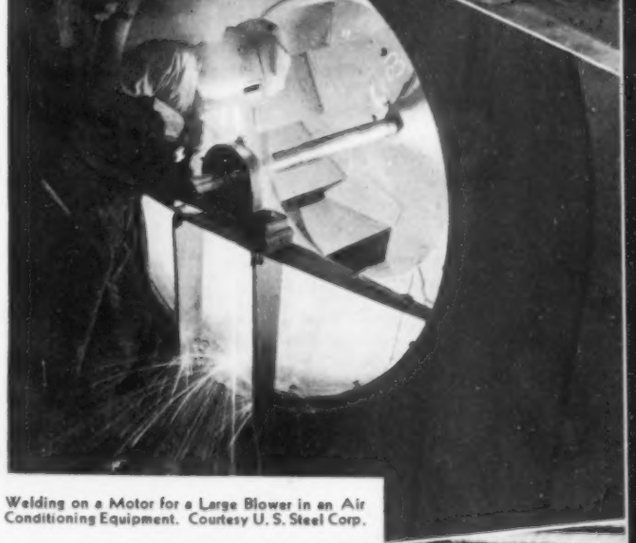
elding Is the Accepted Production
, Superiority of Product and Reliability

ONE of the first to use welding extensively, the refrigeration industry, today depends more and more upon this method of making gas tight joints in pipe lines, pressure vessels, coolers and many other kinds of uipment. Welded work is particularly preferred for plants charged with pensive refrigerants as some of these leak very readily and being odorless e no warning of the fact that it is being wasted. It being nothing uncommon a charge of gas for a single plant to cost from three to five thousand dollars. Welding has increased the efficiency of up-to-date evaporators by per-tting greater velocities, thus increasing the heat transfer.

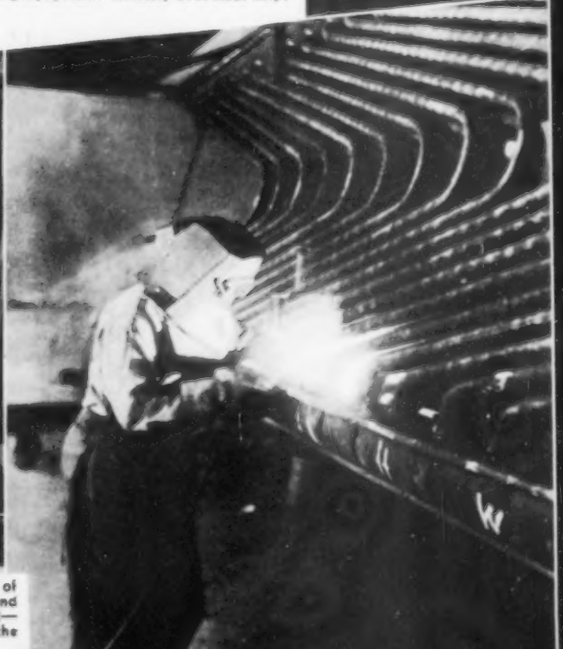
Fast freezing is occupying the minds of food scientists as a means of pres-ation. In defrosting, temperatures will vary from a minus 25 degrees to s 60 within five minutes. Under these severe service conditions welding withstood the test. Some of these systems require more than a thousand lded joints of various types.

Welding is assisting in the air conditioning of literally hundreds of different ustries. The deepest mine in the world—8500 ft. below the surface—a welded air conditioned system.

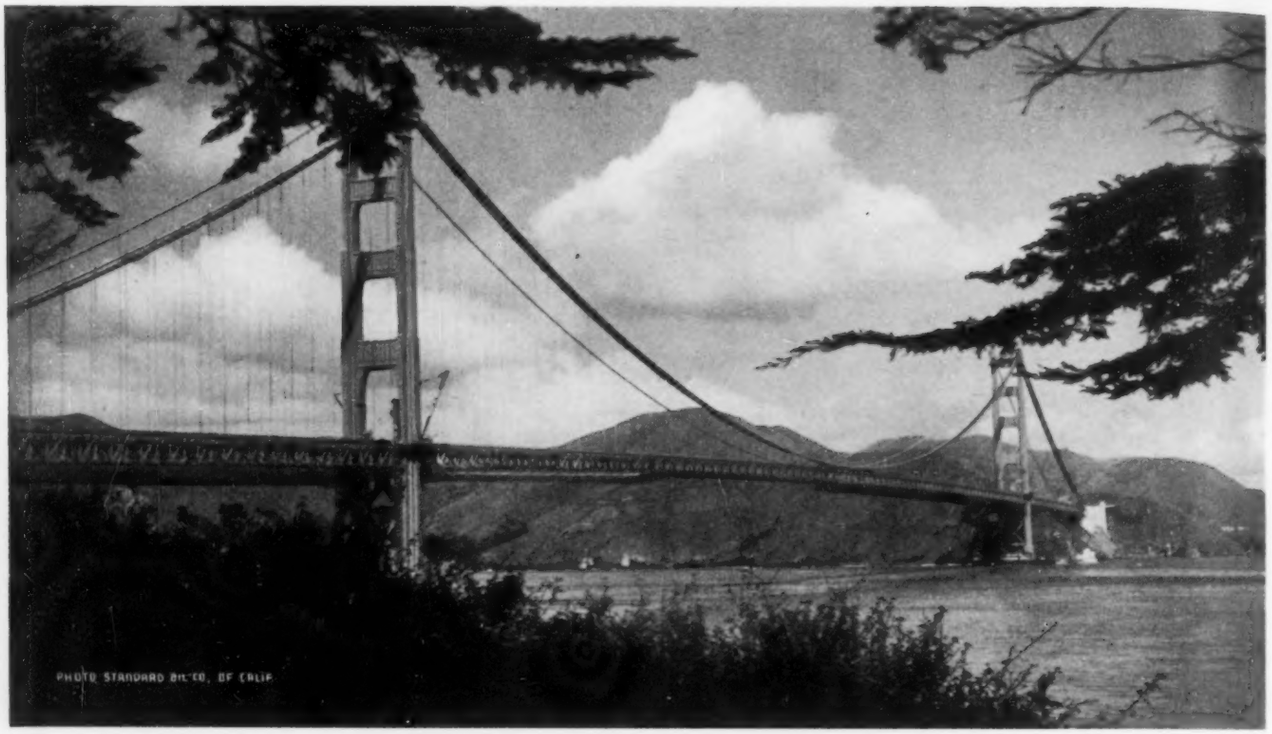
The popularity of household mechanical refrigeration is due in no small sure to economies and mass production methods made possible by the of the various welding processes.



Welding on a Motor for a Large Blower in an Air
Conditioning Equipment. Courtesy U. S. Steel Corp.



Left—Colorful Light—Glowing Red, Yellow and White—Intense Heat as Mile After Mile of
Pipe Is Welded Into Varying Lengths. Right—These Are Shaped in Special Machines and
Welded Into Headers, to Resemble in Their Completed Form Some Giant Prehistoric Animal—
Courtesy York Ice Machinery Corp. Above—An Expert Welder Joins Delicate Parts of the
Freezing System of the Servel Electrolux Refrigerator



The Golden Gate Bridge Spanning the Entrance to the Famous San Francisco Bay

The Golden Gate Bridge Is Completed

By E. L. MATHY†

THE mightiest single span suspension bridge ever contemplated by man has been completed and was opened to the traffic of the world on the morning of May 28, 1937.

Innumerable statistics pertaining to this great bridge and the San Francisco-Oakland Bay Bridge (put into service a few months ago) have been written and are yet to appear. To all those interested in the achievements of modern science of metals and the ingenuity of engineers, this vast structure is a fascinating example of human skill —to those particularly interested in the widening scope of welding and cutting, it will signify the future enlargement of the possibilities of these processes.

While this structure is not—as many of us might have wished—truly a welded creation, both the electric arc and the gas cutting process were employed in many of the preliminary as well as structural phases.

Because this bridge has not as yet been described in "THE WELDING JOURNAL," it may be permissible to give but a few of the essential factors in order to more fully appreciate its vast magnitude, as well as its great importance in a mighty highway system. Linking, as it does, San Francisco with the Redwood Empire to the north and spanning, in a single suspension bridge, the GOLDEN GATE, it forms the final and major link of the All-Coast Highway from Mexico into Canada.

Ground breaking ceremonies were held on February 26, 1933, and in approximately four years' time and at the expenditure of over $35,000,000 (not counting the cost of the approach highways, etc.) the bridge was completed. Cold figures of dimensions are not often impressive but they must suffice to offer a conception of size. Its two great towers rise 746 feet above sea level; its main span measures 4200 feet; 7700 linear feet of $36^{1}/_{16}$ inch diameter cable were spun out of 27,572 individual wires, the total length of which measures 80,000 miles. These mighty cables weigh 22,000 tons and are supported or do suspend a mass of 85,000 tons of structural steel. Including 9200 feet of approach viaducts, the total structure covers $3^{3}/_{4}$ miles in length and offers, to navigation, a clearance of from 220 to 246 feet in height.

Standing on its wide deck, provided with two ten foot sidewalks and with a driveway sixty feet across, one may enjoy one of the greatest sights imaginable. Looking toward the North are the towering hills of Marin County, with Mount Tamalpais as the center. Looking Southward lies San Francisco built upon innumerable hills, as far as the eye may reach, bordered by the waters of the great Pacific, the Golden Gate and the San Francisco Bay. Looking to the West is the entrance to the Golden Gate—is the vast expanse of the Pacific and lie the Farallon Islands. Here is the pathway of ships destined for the ports of the world, and the mighty Clipper ship here leaves the continent on its journey to Hawaii, the Philippines and China. Looking Eastward can be seen the San Francisco-Oakland Bay Bridge and a background of home-studded foothills.

It took four years to build the bridge—it took seventeen years to overcome the innumerable handicaps.

† First Vice-President, Victor Equipment Company.

Large Bombs with Welded End Points

Perhaps a few more figures might be palatable. A freight train twenty miles long would have been required to carry the over a hundred thousand tons of materials needed. The San Francisco Pier covers a square area of 90 by 185 feet, having a height, above bed-rock, of 144 feet. Over 260,000 cubic yards of concrete was poured—enough to build a solid shaft 25 feet square and two miles high. The bridge is large enough to accommodate 283,000 automobiles every twenty-four hours.

It was only fitting that the opening ceremonies should have employed three cutting torches which were used by Angelo J. Rossi, Mayor of San Francisco, Frank P. Doyle, representing the Redwood Empire and William P. Filmer, president of the Board of Directors of the Golden Gate Bridge and Highway District, to sever three chains —a gold, a silver and a bronze link. To offer you a complete account of all of the welding and cutting operations employed might prove too difficult, since it involves many auxiliary operations conducted in shops located from Coast to Coast. Under these circumstances, there are mentioned here only some of the applications which came under the personal observation of the writer, and those specifically called to his attention by the Pacific Bridge Company—the general contractors.

Welding proved indispensable, throughout the work, in meeting many complicated contingencies. Throughout the construction of the piers of this bridge, for instance, it became necessary to adapt a steel structure to submerged rock measurements which could not be obtained sufficiently in advance on account of the inaccessibility and rough water. To design a riveted structure, have it approved, get it detailed in the fabrication shop and secure the finished steel from the fabricator to the works would have required time which was not obtainable.

The first unit to be constructed was the Marin cofferdam. Here an irregular sheet pile bulkhead was built against a backing of cribs and timber bents later embedded in an earth and rock dike. The sheet pilings used were those left over from the Pacific Bridge Company's shops in Sacramento, California, and from the

Typical Fender Section Ready for Lowering

Southern Pacific railroad bridge foundations built at Benicia, as well as some utilized at the Hetch Hetchy water crossing of the San Joaquin River—quite a varied assortment of lengths and sizes. The site of this particular pier was eroded greenstone and very irregular. Some of it was under 35 feet of water and some of the rock was covered by an overburden of sand and gravel. To cut off some sheet piles and lengthen others to fit this rock formation, and to fit up the iron work of the irregular bents supporting these sheet piles, cutting and welding equipments proved invaluable. The Marin pier (the north pier) has several layers of reinforced steel beneath the tower seats. This required a structural support capable of carrying the weight of this steel down to the concrete base. A welded frame was made out of used pipe and rod bracing for this purpose.

The excavation for the San Francisco Pier was carried out by the Camp Bombing Method, patents for which are now owned by the Pacific Bridge Company. An untold number of pilot bombs were necessary for this, which consisted of small cast steel points welded into the ends of $2^1/_2$-inch pipe 2 feet 6 inches long. This joint had to be water-tight and was accomplished by a continuous weld between the end of the pipe and the shoe. Also, at eight foot centers both ways over the pier area and in several lifts, main bombs consisting of 8-inch pipes about 8 foot long were driven in holes previously sprung for them by the pilot bombs. The use of welding permitted the making of these bombs out of used pipe, the lower

[Bottom Fender Section Moving Out Connecting Trestle to Site of South Tower

Marin Cofferdam Under Construction

The San Francisco Pier fender consisted of a series of rectangular steel frames closed with 1/8-inch skin plate on all four sides. This fender was 34 feet long and 27 1/2 feet wide and about 20 feet high, and fitted with jaw castings to slide down on 104 pound rails attached to the sections already in place and concreted. On account of the necessity of fitting the bottom, measurements for which could not be obtained until after completion of the excavation, the bottom section of each unit was a cage made of steel beam wales with suitable rod bracing and wooden panels, properly weighted, were lowered to divers and bolted up against these wales. These wales and panels were largely recoverable, and welding proved indispensable in fitting these sections together in short order, and in altering the beams and rod bracing for subsequent sections. The attaching of the skin plates to their supporting beams and stiffeners was done by welding in the fabricating shop, and saved much weight.

end being closed by cutting four grooves on the end of the pipe, bending them in and welding them together. Large economy resulted from making the bombs in this manner.

The guide tower which was set-up at the end of the access trestle for the San Francisco Pier and used as a starting part for sliding the fender sections down through 100 feet of very rough water came out as a carefully fabricated unit with column centers about 8 feet by 30 feet. The legs of this frame had to be inserted in 26-inch steel tubes previously driven in the rock in about 107 feet of water. As this work could not be very accurately done, corrections had to be made to the base of the guide tower to make it enter the four tubes, and this was done with welding equipments, assisted by preheating torches.

Welded Side Wall of Fender Section Being Transported

Guide Tower on Barge Ready for Lifting

A certain amount of play had to be left in the jaw castings of this frame. When the fender frame was about half completed, it became evident that a small correction would be necessary in the horizontal frames of each end section to make the fender close. The alterations were accomplished by welding methods with the loss of only one day's time. Some damage was done to the fender frame by the caisson in the storm which came about October 10, 1934 when the attempt was made to place it. The rectification of bent members and other damage was corrected by welding at the site. A welded frame made out of scrap steel was used to support the reinforcing steel for the San Francisco Pier, the same as on the Marin side.

The methods for building this pier were largely tentative on account of its unprecedented nature, and soon resulted in the accumulation of large amounts of discarded

Preliminary Chain Cutting Ceremonies at San Francisco City Hall Rotunda with Mayo Angelo Rossi, Wm. P. Filmer and Frank P. Doyle, Assisted by Messrs. E. L. Mathy and E. A. Daniels of the Victor Equipment Company

and scrapped steel. This proved an invaluable source of supply, for all the "gadgets" and miscellaneous steel devices desired by various foremen and mechanics through the work, on very short notice. The advantage of being able to manufacture anything, on short notice, out of available steel scrap is of tremendous importance to the contractor and a great recognition to the flexibility and economy of welding and flame cutting. To the mechanical department of any small or large construction job, welding and cutting equipments are utterly indispensable and proved themselves so, very definitely, during the construction of the GOLDEN GATE BRIDGE.

In the construction of the bridge deck, welding was used very extensively. The reinforcement consists of transverse trusses made of $^{11}/_{16}$-inch plain round chord bars and $^{7}/_{16}$-inch plain roud web members welded together at intersections. This was done at the plant of the Concrete Engineering Company, sub-contractors for the reinforcing steel in the deck. These trusses were set up on 1-inch square steel blocks on top of the steel stringers. The trusses were welded to the blocks and the blocks to the stringers. This made a field welding job, also done by the concrete Engineering Company; six welding machines were used, simultaneously, at one time. The use of welded trusses for deck reinforcement of large bridges has become almost standard practice. It was used also on the San Francisco-Oakland Bay Bridge, the George Washington Bridge in New York and the Delaware River Bridge, between Philadelphia and Camden.

Expansion joints were made at 50-foot intervals across the roadway and sidewalks of this bridge, using the method developed by the American Concrete Expansion Joint Company; namely, a premolded elastite section wired down over a copper water stop to two $^{1}/_{4}$-inch steel plates on edge, welded to steel floor members on either side of the joint with suitable plate braces. Making up these plates and braces and attaching to the steel proved another instance where welding was indispensable.

The author would like to express his appreciation for the fine cooperation offered him, in the preparation of this article, by Mr. Fred Crocker of the Pacific Bridge Company of San Francisco, California.

Shipyard Installation

By IRA B. YATES†

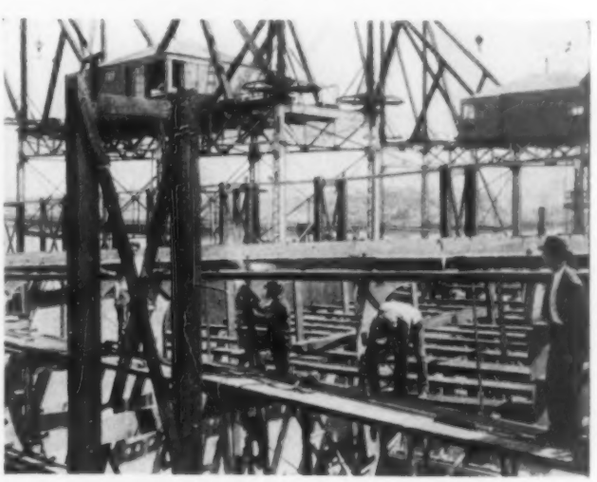
ABOUT a year ago, in line with an expansion program, the United Dry Dock, Inc. made a complete survey of the arc-welding equipment and requirements at their Staten Island plant. Up to that time they had been using quite a number of portable single operator arc-welding machines, and their survey showed that this equipment was deficient in the following respects, briefly discussed:

1. The space requirements in and around a ship under construction are very limited. A large number of men work in a confined area, and therefore single operator sets had to be placed far away, with considerable power loss resulting from the extra long welding cables required.

2. A hazardous situation was created by the multiplicity of temporary wiring required. All high voltage wiring had to be protected from grounding on metal parts and from moisture conditions.

3. The plant had a large induction motor load, and included in their power rate was a stiff penalty for low power factor, caused by the additional arc-welding equipment.

In view of the foregoing conditions, it was decided that their welding requirements could be best met by the installation of a constant potential equipment. The generators could be driven by synchronous motors and not only eliminate the low power factor welding load, but correct the low power factor load in other parts of the plant. In this way not only were all hazards and inconvenience dispensed with, but the total efficiency of the plant load was increased.



† General Sales Manager, Wilson Welder & Metals Co., Inc.

Welded Steel in High Speed Railroad Service

By EVERETT CHAPMAN†

HIGH speed railway service demands structures of light weight and high fatigue strength. These basic requirements have been adequately met with welded alloy steels.

Two dangerous periods in the evolution of a high duty, light weight welded steel structure are: (1) The design, and (2) the manufacture.

The Design Period

To reduce weight and still have a serviceable structure in the face of certain hypothesized load conditions the designer must first choose a material which will enable him to work at higher stress levels than are usual with mild steels.

"Serviceable" light weight equipment imposes a further requirement that is by no means supplementary.

The measure of serviceability is the ratio of the average stress level to the maximum stress, wherever it may occur. Hence, when lightening a structure by raising the design stresses in a suitable medium, great care and attention must be given to the sculpturing of the corners and contours. This is extremely important in high speed railway service where the dynamic augment may exceed values given by experience at slower speeds. The use of higher strength alloys working at higher stress levels does not by any means constitute an additional factor of safety, but, on the contrary, extra care should be taken to ease all boundary conditions where a change of direction is involved. Figure 1 shows an application of this nature. Some designers have been known to suffer complete relaxation when presented with high physical values by test out of research.

Welded steel designs should be scrutinized very carefully with respect to details of the joint, and boundary conditions. A welded steel joint is either one hundred per cent rigid or is broken. This is not so with the riveted joint in which the rivets can lose their bearing without complete failure of the joint occurring. The 100% rigidity of the welded joint is the seat of all the advantages and the cause of most of the troubles of this method of fabricating. It can and will transmit the full bending moment applied to it, making the structure truly continuous. Because of this, it must be capable of transmitting the full moment and under repeated applications. Every detail of the joint must be carefully scrutinized for stress concentrations. The technique of making a joint exhibiting a uniform stress distribution must be thoroughly and rigidly defined for the fabricating shop. This is very often one of the controlling factors of the design. For instance, a completely closed box section cannot be butt-welded satisfactorily to another completely closed box section so as to develop the full areas involved for a pulsating load, because the back side of the weld cannot be treated to eliminate the unfused root of the weld made from the outside. Some ingenuity is necessary in this case.

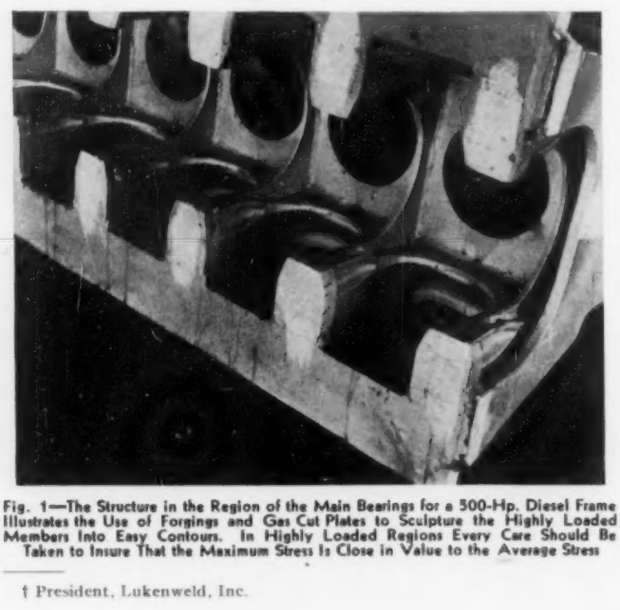


Fig. 1—The Structure in the Region of the Main Bearings for a 500-Hp. Diesel Frame Illustrates the Use of Forgings and Gas Cut Plates to Sculpture the Highly Loaded Members Into Easy Contours. In Highly Loaded Regions Every Care Should Be Taken to Insure That the Maximum Stress Is Close in Value to the Average Stress

Fig. 2—The Top Deck Structure and Side Plates of a 1500-Hp. Diesel Engine. This Shows the Machined Transition Member in Place Before Welding. The Gas Load Is Carried from the Top Deck Through the Side Plates and Transition Member in Straight Lines to Its Reaction

A great deal of thought must be given to the selection to the proper structural shapes that will best adapt themselves to the imposed load. It is in this respect that the designer will find welded steel construction to be the most flexible and pliant medium that he has at his command. There are no serious limitations of shape or wall sections to be encountered. For a member whose load is predominately torsion, the tube is immediately available; if a load is dominately bending, the I section or rectangular box is available. If the tube and the rectangular box must intersect, a transition casting or a pressed member nicely shaped to effect gradual changes of contour can economically serve as the joining member.

A common design mistake is to select the wrong shape for the imposed load. For instance, a channel section for twist is a poor choice and the attempts to proportion this channel for the torque results in a mathematical fiasco.

† President, Lukenweld, Inc.

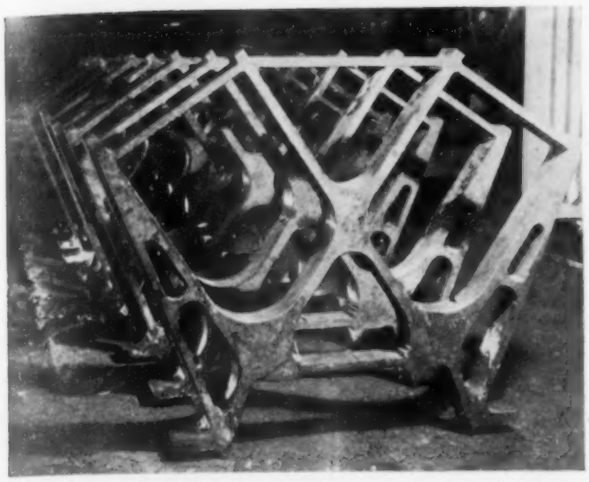


Fig. 3—Gas Cut Main Frame Members for 1200-Hp. Diesel. These Main Strength Members Were Gas Cut from a Plate of Hi-Strength Alloy Steel. The Gas Torch in a Case Like This Enables the Designer to Sculpture the Shape of the Members. Welded Steel Construction Is Not Necessarily Angular and Slat-Like

The channel, it is true, can transmit torque but it is the wrong choice for such a load on two counts: (1) The average designer does not know how to calculate the maximum stress in such a twisted member, has no idea how it acts and flounders around in a maze of misapplied polar moments of inertia, and (2) It is not the most economical member or section to transmit torque.

Another illustration of the same thing is the tendency to tie a load to its reaction in seemingly the most indirect manner possible. Certainly the lightest member is one acting in pure tension and certainly a member in pure tension can be calculated by more people than can calculate a member which curves and wanders about and has all sorts of odd little eccentricities in it. True enough, we sometimes have to use a C frame to meet some space requirements, but even so in the interests of light weight, the throat should be as small as practicable. An example of this thought of keeping steel in straight tension so that one can calculate it and know more about how it is acting is shown in Fig. 2. It shows the top deck and side plate structure together with a transition member. Here the gas load in each bank of cylinders must get to the common reaction point, the crankshaft. The minimum amount of steel to safely transmit this load will result when the gas load and the crankshaft are connected by straight lines. At the intersection of the two inner members a contour change needs special attention since the presence of one constitutes an excrescence on the other, and we may reasonably look for a non-uniform stress distribution. Gentle curves sloping into one another ease up the maximum stress value immensely. This blending of one into the other is accomplished by a machined member serving as a transition piece at the critical point. Figure 3 shows another type of Diesel main frame member. Once the ideal shape has been worked into the design, one can confidently calculate the stresses and run them to a fairly high value.

The Manufacturing Period

One of the greatest hazards while the piece is being welded is the possibility of the occurrence of cracks which are undiscovered and remain in the finished structure when it goes to work. The combination of steel and heat can produce unbelievable results. The combination in the case of a welded structure can be quite disturbing. The distinguishing features of a weld is that the localized application of heat always results in severe temperature gradients. This means two things: (1) Rapid flow of heat from one place to another (quenching), and (2) Thermal stresses are produced which do not vanish as temperature equilibrium is established. Thermal expansion and contraction is a reversible-phenomena only when the temperature is uniform.

The quenching of the parent metal by the rapid flow of heat from the hot zone around the weld to the colder zones away from the weld is only to be considered hazardous if the nature of the parent metal is such that it will harden. Hardenability is, of course, a function of the same variables as high strength; namely, carbon content and, to a lesser degree, alloy content. Thus, the steel maker when asked to produce high strength welding steels is immediately faced with the problem of producing high physical values at very low carbon contents. There have been many interesting solutions to this problem in the last five years, some of which are admirable and some of which tried to overcome this basic welding axiom by mixing wish thinking with carbon. Unfortunately, and as usual, nature paid no attention to this type of solution.

One of the best steels, in the writer's opinion, is the low-carbon manganese molybdenum type. While its physical properties at low-carbon contents are not quite as high as some of its contemporaries, it is one of the most foolproof, dependable steels on the list and welds beautifully. It is the writer's considered opinion that 0.18 carbon represents the maximum content that will be trouble free. When considering the manufacture of alloy steel of this low-carbon content, the nature of the alloys must be such that they can be introduced in the steel without oxidizing. Otherwise the steel will be excessively dirty and laminated. This condition is not usable in a steel which enters a welded structure since, contrary to a riveted structure, where the rivets work in shear against the entire cross section of the plate, the steel can be loaded in three directions. The reason for this excessive dirtyness in the case of the improperly chosen alloys for the low-carbon ranges is that the open-hearth mechanism which reduces the carbon in the bath is one of oxidation. By the time the carbon is down to 0.10 or 0.12 the bath is highly oxidized and great care must be used in the technique of cleaning up the bath and in the choice of the alloy additions.

The manganese moly type of steel seems to be a satisfactory compromise between all the factors to be considered. High physical properties are by no means the only defining characteristics of a steel for light weight high duty structures. A seventy-five thousand pound steel that is able to survive the ordeal by design and

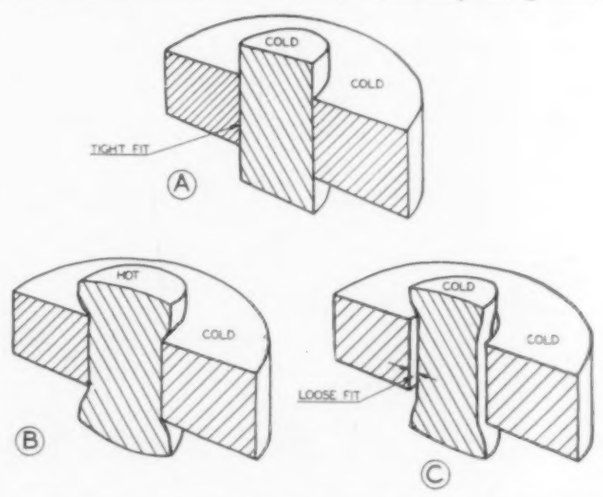


Fig. 4—Schematic Representation of the Action of Thermal Gradients in Setting Up Locked-Up Stresses

Fig. 5—Root Conditions at Various Angles, Currents and Rod Sizes

fabrication and enter service uncracked seems far more equitable than a hundred thousand pound steel with a crack in it.

Again it must be pointed out that initial local hardening due to the cold parent metal quench would not cause fabrication cracks in the welded structure were it not for the stresses that are set-up during welding by this same heat that causes hardening.

The phenomenal of thermal expansion and contraction being non-reversible in the case of non-uniform temperature distribution is a very interesting one and has far reaching consequences in a welded structure. These resultant stresses can be easily equal to the yield point of the metal and further, the system of stresses can be such that the apparent or working ductility of the steel is reduced to 10% of the tensile test value. The irreversibility results from the fact that the steel is not the same shape after it cools as it was before it was heated. The seat of this irreversibility under non-uniform heating is that the cold portion of the configuration acts to rigidly constrain the expansion of the heated portion. At some point in the region where the temperature gradient is high, the yield point of the material is exceeded. A plastic deformation occurs and the hotter metal will upset, becoming thicker and shorter than it was with reference to the initial temperature. As the piece cools this shorter and thicker region now pulls against the initial constraining portion and in the final state of temperature equilibrium a complex two-dimensional state of internal locked stress exists. Its severity is a function of the initial temperature gradients and the adjacent rigidity. This mechanism can be illustrated as shown in Fig. 4. Suppose that a plug is tightly fitted in a hole in a steel disk (Fig. 4*A*), and that this plug is heated by electric currents running through it. The diameter of the plug tends to get larger but its free expansion is constained by the disk. If it is hot enough it will take a shape as shown in Fig. 4*B*. Figure 4*C* shows the result after the plug and disk have cooled to room temperature. The plug is now a loose fit in the hole by a few thousandths of an inch. In the actual case under discussion this looseness of fit would have to be made up by elastic strains in the plug and disk and severe stresses would exist.

If the steel is hardenable, a highly quenched non-ductile zone will exist in the neighborhood of these heat stresses. It is more than likely that a crack will occur under these conditions. These fabricating cracks are difficult to locate and repair and may exist in the finished structure where they are a source of failure under a fatigue load. A good example of this is the building up of journals by welding. An 0.50 carbon steel axle requires a very careful and involved welding technique if it is to be welded without the production of a multitude of fine microscopic cracks. Experience has shown that these axles should not be entrusted to the technique of the average shop. A fool-proof steel for welding should not contain more than 0.18 carbon.

The phenomena just outlined are the reasons why every welded steel structure for high duty should be heat-treated in a proper furnace before it goes into service. The temperature should be high enough to restore some ductility to the hardened zones and the time in the furnace should be long enough to allow the internal stresses to readjust themselves. It is a two-fold treatment. It is not enough to attain a certain temperature

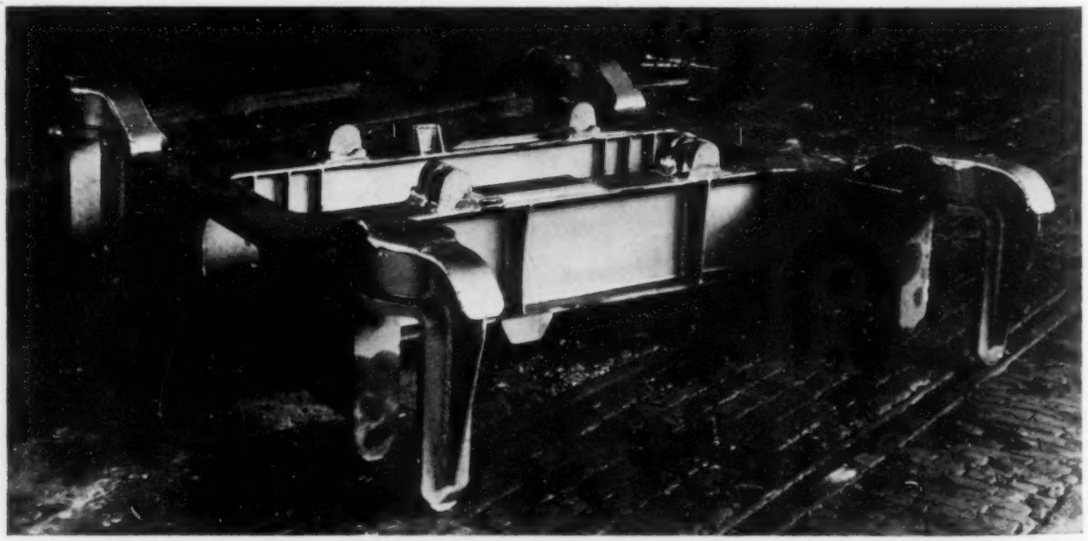


Fig. 6—Alloy Steel Subway Truck. This Truck Weighs About 1600 Lb. and the Center Plate Load Was 45,000 Lb. Stress Level 24,000 Lb. per Sq. In.

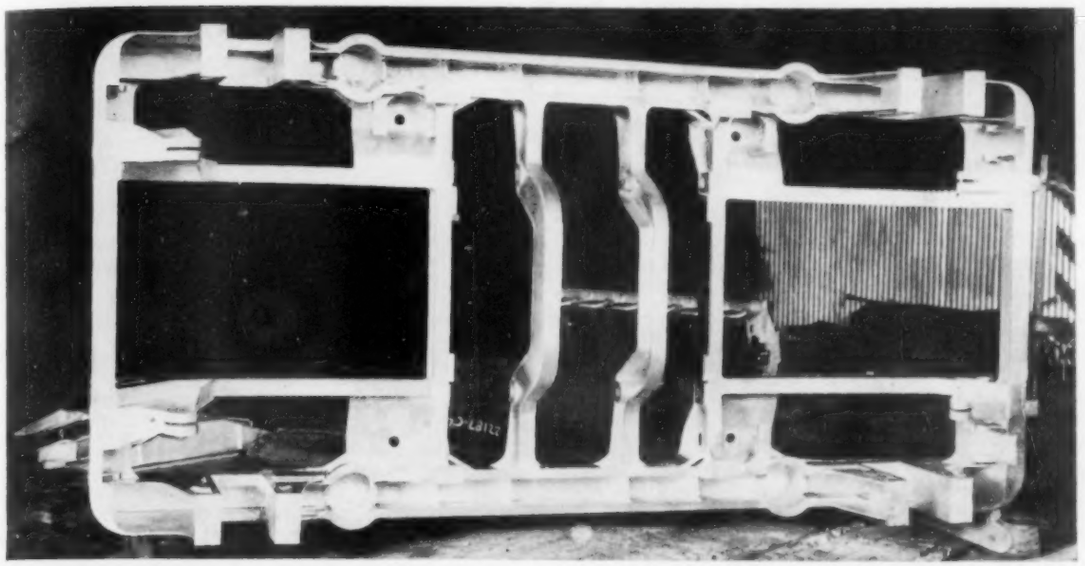


Fig. 7—An Example of Extremely Light Weight Trucks. The Use of Welded Alloys in This Instance Enabled a Smaller Size Axle to Be Used. This Is a Truck for an Electrical Flaw Detector Car and the Use of the Larger Axle Would Have Called for a Complete Redesign

throughout the piece in order to accomplish the breaking down of hardened constituents. The readjustment of the total structure to eliminate or minimize residual stresses is a phenomena of creep. Sufficient time at the stress-relieving temperature must be allowed for the material to flow. Temperatures of 1200° F. have been found to be adequate while a criteria of two hours per inch of maximum thickness seems to remove all residual stresses of practical consequence. The behavior of the welded structure while it is being machined is a good indication of the state of stress. A squirming structure is not free from stresses. The 1200° F., 2-hour per inch treatment seems to deaden most structures for the machining operation.

The two dimensional nature of the thermal stresses in flat plates may have serious consequences. The stresses exist in two directions because the temperature gradient existed in two dimensions. If the locked stress system assumes the form of a bi-axial tension, the ductile properties of the steel are almost completely inoperative as a corrective mechanism. The second set of tensile forces at right angles to the first, inhibit the normal lateral contraction of the steel as expressed by Poisson's ratio, and under these conditions shearing action cannot take place. The steel shows an apparent ductility of about 6%. A practical case where this mechanism actually causes failure occurs in the bending of long thick plates for pressure vessel shells. A piece of good steel of 3-inch x 3-inch cross section will bend easily around a 6-inch pin through 180°. If a section is cut through the portion of greatest ductility the 3-inch square will now appear as a trapezoid; the tension side having laterally contracted and the compression side laterally expanded. The lateral deformation has not been inhibited. If a 3-inch thick piece of the same steel 120 inches square is bent in a bending roll into a shell the steel will break at an elonga-

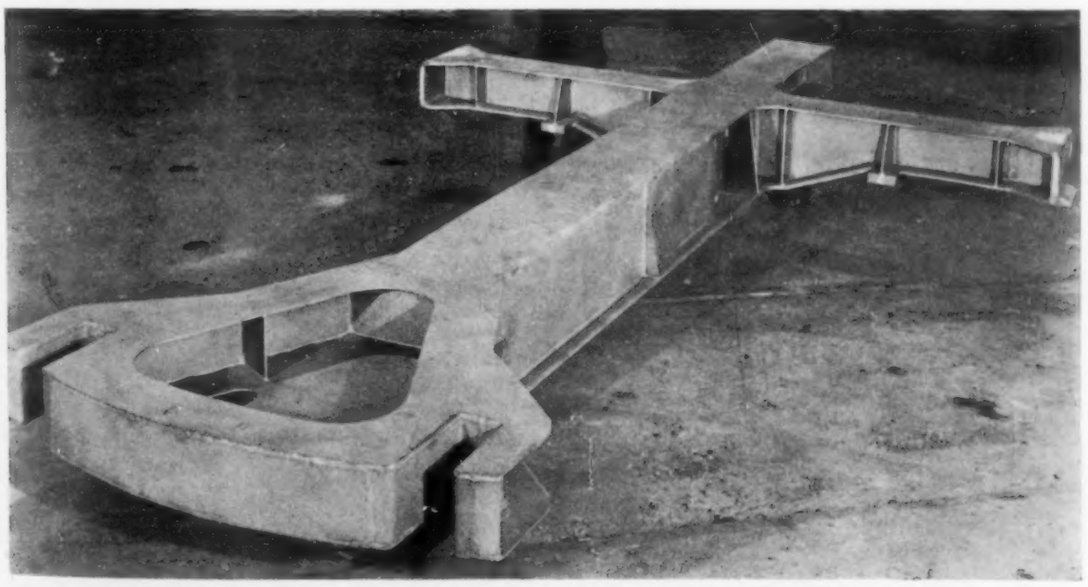


Fig. 8—Two Underframes for Light Weight Shot Welded Stainless Steel Cars. These Frames Weigh Around 2500 Pounds and Are Made of Cromansil Steel. Cromansil Steel in the Lighter Gages and at a Carbon Content Suitable for Welding Shows a Yield Point of About 60,000 Lb. per Sq. In. and an Ultimate of 85,000 Lb. per Sq. In. These Frames Take the Center Plate Load Together with All Draft and Buff Loads. Their Service Record Has Been Satisfactory in Spite of the Thin Gages and Higher Stresses. The Stress Level in These Frames Is Around 24,000 Lb. per Sq. In.

tion corresponding to about six per cent, in contrast to the exhibition of ductility of about 30% in the small specimen. This is due to the inhibition of the lateral deformation by the remainder of the plate outside the bend line. It is necessary to bend these steels either hot or in a series of small arcs whose incremental change does not represent a plastic stretch of more than about five per cent.

In a welded joint the combination of hardened zones and odd thermal stress systems may have a third inherent evil present to insure that the joint will not withstand fabrication stresses or a fatigue load in service. The root of a weld, which is the portion of the weld where the first bead was deposited is very difficult to thoroughly fuse. The beveled groove is an acute angle, and the molten pool freezes before it can melt the sides near the bottom. The result is that an internal crack is formed in the interior of the weld. The crack is that portion of the boundaries of the two original plates that were not fused together when the joint is integrated with the arc. These unfused boundaries form internal discontinuities that may be very abrupt and sharp. Figure 5 shows several attempts at various currents, rod sizes and angles to eliminate the root crack by complete fusion. Only the initial bead has been deposited since it is the bead in question. The results are not usable. To make a butt joint with no internal crack it is necessary to chip from the back into the first bead and then reseal the groove with a weld from the side that was chipped. Such a butt joint will exhibit properties under any kind of load that are equal to or better than the parent metal.

Caution must be observed in the use of fillet welds since they have a large unfused root. The internal boundary is a potential rip that will easily propogate itself through the throat of the welds under fatigue. Fillet welds in fatigue service should only be used in shear and even then attention must be paid to the ends of the weld where shear contractions exist.

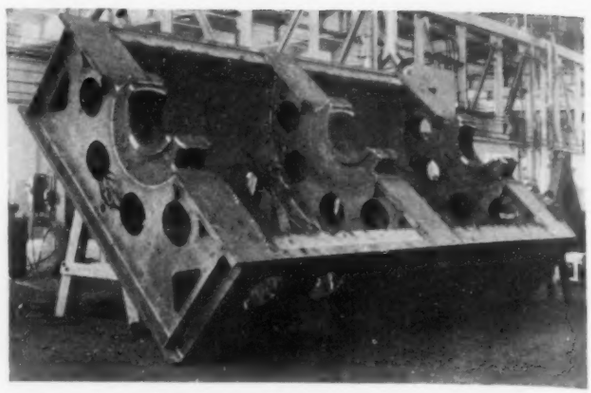


Fig. 9—Bed Plate for Two Cylinders of a Four Cylinder 5000 Hp. Slow Speed Marine Diesel. The Weight Saving in This Instance Over Cast Iron Is in the Neighborhood of 120 Tons. This Is Roughly 20% of the Weight of the Entire Engine. This Bed Plate Is 30 Feet Long and Weighs 55,000 Pounds

If the basic principles that have been outlined are combined with good designing practice, welded steel structures can be evolved that are lighter than conventional construction. The service records of various pieces of equipment to date have fully justified the use of welded alloys.

Figures 6 to 10 will partly outline the applications that have been made.

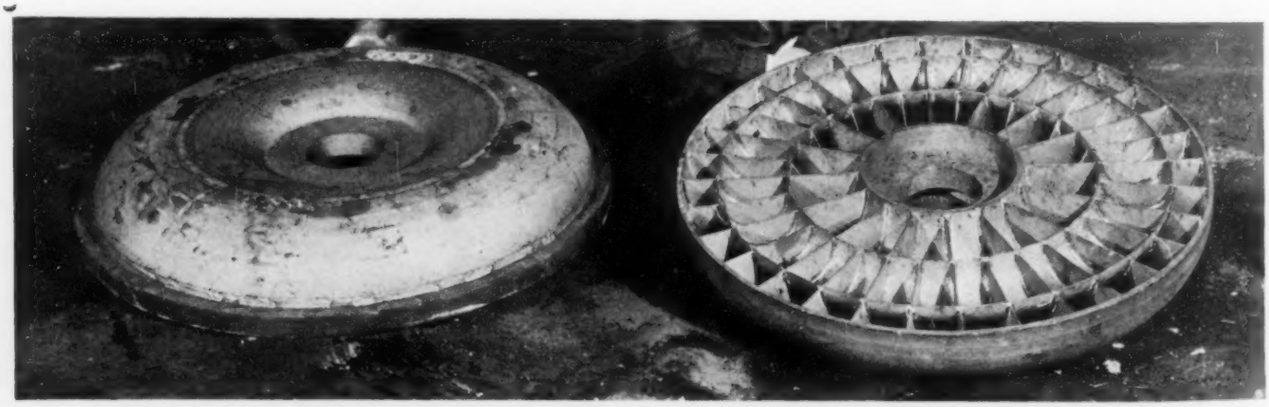


Fig. 10—Weldment for an Oil Coupling Used Between a Diesel Engine and Reducing Gear for Uncoupling the Engine and Absorbing Torque Pulsations from the Engine That Would Otherwise Get Into the Gears. The Vanes in This Coupling Are One-Eight of an Inch Thick. The Bowl Proper Is a Forging Combined with a Pressed Head

Don't Miss the Annual Meeting!

Every member is urgently requested to study carefully the Annual Meeting Program given elsewhere in the Journal. Papers will be printed in advance. Discussion of these Papers will be exceedingly important to every one connected with welding. Make your reservation at the Traymore Hotel, early. Space is going fast!

Light-Load Steel Framing for Residences

By GEORGE E. ROUTH†

THE much discussed steel framed dwelling house as a thing of the near or remote future is now rapidly becoming an important current development. Steel framing is arriving on the home building lot along with brick, stone, wood flooring or sheathing and other accepted home building materials for use in the type of home that is also currently accepted. The progress that has been made in the past few years in applying so-called light-load framing in apartment houses and a wide range of small structures closely resembling residence types largely accounts for this development.

A present example of the application of steel framing of this light-load type, evolved from its earlier application to other types of light-load structures, is furnished by open-web light-load type studs and joists as they have been recently adapted to home building requirements by the Bethlehem Steel Company. By aid of electric arc welding and flame cutting these open-web design members are now being employed in residence construction in much the same way that wood framing is. The main difference is that the acetylene torch is employed

Baker Residence at Olyphant, Pennsylvania

Two Early American Farm Houses Erected by Richard S. Kerns at Ardmore, Pennsylvania

in place of a saw to do whatever cutting and fitting of the steel members that is called for and the field electric welder takes the place of hammer and nails. The steel is delivered to the lot cut in standard lengths. Qualified welders fabricate it. A man experienced in laying out ordinary wood framing supervises the work.

Houses in which this steel framing has been utilized range in size from six to twelve rooms or more, and in cost from $6000 to $125,000. They are located in such representative states as Massachusetts, New York, Pennsylvania, Delaware, West Virginia, Georgia, Texas and California. The types of architecture range all the way from orthodox American and English types, and their current modifications, to modern. And, indeed, its adaptability to familiar and well-established styles of dwelling house architecture as well as to modern design is considered to account in no small degree for the wide acceptance it is winning.

The open or latticed web design of the light-load joists and studs that are utilized eliminates non-working weight, and provides a steel member, minimum thickness $^1/_8$ inch, that is somewhat heavier than a wood joist or stud, but to compensate for its greater weight is also stronger and more rigid. Few of the steel members required in a house of ordinary design weigh more than 100 lb. and most of them weigh less than 50 lb. Hence, no hoisting equipment is necessary to lift the steel members into place. The greater strength of the steel members permits spacing them on 24-inch or 30-inch centers rather than on the 16-inch centers that are standard in framing with wood. The total weight of the erected

Murdock Residence at Squantum, Mass.

† Manager of Sales, Building Specialty Division, Bethlehem Steel Co.

Cutting Open Web Steel Framing to Length

framework is, as a result, no greater than that of wood construction.

The steel framing makes possible fire-resistant floor and wall construction, provides lasting protection against termites and eliminates the troubles of shrinkage that must be reckoned with in wood framing. The added cost of this construction, including the extra cost of fireproof sub-flooring and plastering on metal lath is estimated to be 5 to 10 per cent more than for a similar house of wood construction. This estimate is based on sub-floor construction consisting of 2-inch concrete slabs and metal lath plaster walls and ceiling, on all floors of the typical dwelling house.

One advantage of this type of floor construction when utilized in conjunction with open-web steel joists is its relatively high impenetrability to sound. In tests conducted by the U.S. Bureau of Standards floor construction using steel open-web joists with a top slab of concrete and plaster ceiling below, ranked considerably higher in resistance to air-borne sounds than clay-tile and concrete joist slabs and also ordinary wood-construction floors. And while air-borne sounds are of chief concern in residences it is interesting to note that this construction was also measurably more resistant to sounds caused by tapping or impact than wood flooring.

Contributing to this high resistance to sound is the open-web construction of the joists. This breaks up the metal's natural conductivity to sound. The open-web construction of the joists also facilitates the installation of wiring and piping which can either be run longitudinally between the floors or through the open spaces in the lattice work. Duct work can either be run in the spaces between the joists or by cutting away a single lattice or section of open-web work it can be run crossways to the members when desirable. The joist can be brought back to its original strength by welding in reinforcing plates.

Just as the open-web construction of the members retards conductivity of sound, so the latticed or open-web construction presents no direct path for the transmission of heat or cold. In the completed structure the thermal conductivity of the steel members foots up slightly less than for wood members spaced on 16-inch centers. Either rock wool, inserted in the open spaces between the studs, or insulating board can be employed for insulation.

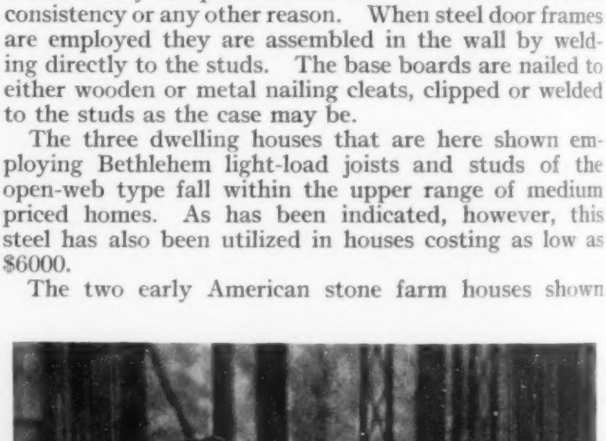
In order to provide a perfectly even footing for the ground floor joists, a continuous $4^1/_2$ inch x $^1/_4$ inch sill plate, grouted in, and bolted at 4-foot intervals into the masonry is provided. The 10-inch joists that meet load requirements in most small structures are welded to the sill plate. Where extra loads are involved, as under hallway partitions, the joists can either be spaced close together or heavier solid-web members can be substituted.

Similarly, 4-inch studding meets the load requirements in walls and partitions for the typical small structure. When braced laterally a 4-inch stud, 10 feet in length has a safe load bearing capacity of approximately 7500 lb. This strength is usually sufficient to make detailed engineering design work unnecessary in ordinary dwellings when not more than three supported levels are carried on stud walls. Heavy concentrations of load on the studding can also be provided for ordinarily without detailed calculations by simply doubling or tripling the studs.

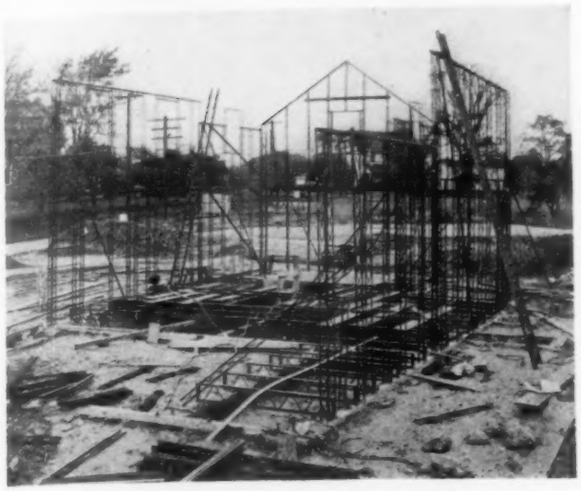
Steel frames for windows and doors carry out the advantages of steel's rigidity and non-shrinking properties to these details. Steel casement windows can be secured to the studs by welded straps without the use of a subframe, or wood window frames and door frames are optional if they are preferred for the sake of architectural consistency or any other reason. When steel door frames are employed they are assembled in the wall by welding directly to the studs. The base boards are nailed to either wooden or metal nailing cleats, clipped or welded to the studs as the case may be.

The three dwelling houses that are here shown employing Bethlehem light-load joists and studs of the open-web type fall within the upper range of medium priced homes. As has been indicated, however, this steel has also been utilized in houses costing as low as $6000.

The two early American stone farm houses shown



Electric Welding of Open-Web Steel Framing



Partially Erected Steel Frame for One of the Ardmore Houses

are the first completed of five houses employing Bethlehem open-web steel framing, now being erected by Richard A. Kerns in the Wynnewood section of Philadelphia and which will be sold in competition with houses of wood frame construction. The two houses that have been completed are of very similar design and built to sell from around $17,000 each equipped with automatic conditioned heat.

Two-inch concrete planks are employed for the subfloors in the ground floor of one of these houses and gypsum plank is employed in the other completed house. The finish flooring is of oak. Both oak squares set in mastic and strip flooring are utilized. The plastering is on metal lath. The window frames are of wood and the finish and baseboard are also of wood.

The second floors are supported by steel joists thus carrying along the steel's rigidity and non-shrinking qualities and obviating plaster crackage that so often has to be reckoned with in wood framed houses, for both floors. The second story floors are of wood construction.

The key to the ground floor arrangement of rooms is a commodious living room which has a fire place and provides access at the rear to a flagstone porch. Dining room, kitchen and laundry are to the right and rear. A first floor study with wash-room toilet that can be utilized as an over-night guest room is to the right. There are three bedrooms and two baths on the second floor, including a maid's bedroom and separate bath. The play rooms contain a play room and game room. Roofs are of slate.

The Raker residence at Olyphant, Pa. an early American type that makes abundant use of gables, was originally designed as a wood-framed house. The change to the use of a steel frame instead did not necessitate changing any of the original drawings or features of its design. The floors in this house are all of oak finish over concrete slabs, except the bath room and kitchen which are finished in tile and linoleum.

In order that the residence might conform closely to its architectural period the lintels are of oak. The windows, on the other hand, are of the steel-sashed casement type, welded by straps to the steel studding. The interior walls with the exception of the finished bath rooms and kitchen, and the living room, done in knotty pine are finished with plaster on metal lath. Wood trim is dispensed with. The doors are hung on steel frames, and a metal base separates the plaster from the floors. The stairs are of steel with wood risers. The approximate cubage of the house is 50,000 cu. ft., and the approximate cost $17,000.

One of the interesting features of the Murdock house at Squantum, of modern design, is the broken up arrangement of floor levels. It is built around its commodious living room which has wide casement windows that provide an unrestricted view of Wollaston Bay. Beneath the living room, is a play room and furnace room, and a few steps up from these is a compact unit of service rooms consisting of a dining room, kitchen, laundry and maid's room. Sleeping quarters are over the service quarters.

The stucco exterior is laid on a non-inflammable cement composition insulating slab. This same form of slab materials laid on the open-web steel joists is employed for the subfloors and also in the partitions and roof construction. Walls and window stools of the play room, kitchen and bath are finished in Formica. The other rooms are plastered and painted.

A wood baseboard is employed but pressed steel door frames dispense with the need of finish or trim about the doors. The roof is flat and will be used as a porch and is waterproofed with standard 4-ply built-up roofing, laid on the cement composition slabs as has been indicated. The cost of the house, without lot, was $20,000.

And so it goes. Each of these houses differs from the others in either some or practically all features of its design. About the same latitude in costs prevail as would in good wooden construction. The steel brings protection against fire and termites, doesn't shrink, warp or sag—provides the best in modern living.

Tentative Rules for the Qualification of Welding Processes and Testing of Welding Operators

The above new Rules were, after intensive work of a large and active Committee covering a period of over two years, issued as a tentative report which was published in the October 1936, issue of the JOURNAL. These Rules have attracted wide attention and have been adopted by several other Committees of the Society for qualification purposes in various Codes and Specifications. In addition the A. S. M. E. Boiler Code Committee has recently taken formal action to incorporate these new Rules in the Unfired Pressure Vessel Code for qualification of both welding processes and welding operators.

While these Tentative Rules propose a complete procedure both for qualifying the welding process and testing the welding operators, the Committee has not undertaken to specify the critical values that should be obtained from the various weld test specimens. The Committee has indicated that it is its opinion that these values should, in all cases, be designated by the code or specification bodies that may adopt these Rules. Par. 9 in both Parts I and II, headed "Test Results Required," merely stipulate that for the qualification purposes intended different minimum test values or criteria should be established for each of the various tests.

While the intent of the Committee in this respect is

clearly stated in the introductory statement published in connection with its report on the above Rules, the import thereof has not been generally understood and many questions have come to the Committee concerning recommendations for the critical values. The Committee has declined, however, to make such recommendations, feeling that this is the prerogative and the duty of the code or specification body that may adopt these Rules. The Committee has conceded, however, that it might be clearer to any one reviewing these Rules for possible adoption if the paragraphs referred to were amplified to show the form in which these critical values are intended to be used. Its report recommending amplification of these two paragraphs, and also a minor correction in Par. 8, Part I, has been approved by the Executive Committee of the Society and the resulting revisions to the Tentative Rules are recorded as follows:

Part I

Section 8 (f)

maximum load in pounds shall be recorded as follows:

Lb. per lineal in. .....
Lb. per sq. in. .....

9. Test Results Required (Revised)

The minimum requirements for the test results are as follows:

A. Butt Welds

(*a*) Tensile Strength. For the reduced-section tension-test specimen the tensile strength shall not be less than.....per cent of the minimum of the specified tensile range of the plate used.

(*b*) Free Bend Ductility. The ductility requirement by the free-bend test method shall be not less than.....per cent.

(*c*) Soundness. For double butt welds the permissible total depth of all zones of defects on any plane parallel to the throat of the weld shall not exceed.....per cent of the thinner of the two parts joined. For single butt welds the permissible total depth of all zones of defects on any plane parallel to the throat of the weld shall not exceed.....per cent of the thinner of the two parts joined. The length of any permissible defect shall not exceed.....in.

Defects are defined as gas pockets,* slag inclusions, cracks and lack of fusion or root penetration exceeding.....in. in greatest dimension. Lack of soundness shall be evaluated by the total depth of all "zones of defects," measurements being made of such depths on a line or plane parallel to the throat of the weld. A "zone of defect" is defined as the area within two lines perpendicular to the throat of the weld and bounding any one defect, or any group of defects whose depths are overlapping. Illustrations of typical cases of "zones of defects" and the total depth of such zones are given in Fig. 22.

B. Fillet Welds

(*a*) Longitudinal or Transverse Shear Strength. The load at failure shall not be less than the following value:

For longitudinal shear test specimen.....
..lb. per lineal inch, or.....lb. per sq. in.

For transverse shear test specimen.....
lb. per lineal inch, or.....lb. per sq. in.

(*b*) Free Bend Ductility. The ductility requirement by the free-bend test method shall be not less than.....per cent.

(*c*) Soundness. The permissible total depth of all zones of defects on any plane parallel to the throat of the weld shall not exceed..... per cent of the specified weld throat dimension.

Defects are defined as gas pockets, slag inclusions, cracks and lack of fusion or root penetration exceeding.....in. in greatest dimension. Lack of soundness shall be evaluated by the total depth of all "zones of defects," measurements being made of such depths on a line or plane parallel to the throat of the weld. A "zone of defect" is defined as the area within two lines perpendicular to the throat of the weld and bounding any one defect, or any group of defects whose depths are overlapping. Illustrations of typical cases of "zones of defects" and the total depth of such zones are given in Fig. 22.

C. Special Welds

(*a*) Tensile Strength. For the reduced-section tension-test specimen the tensile strength shall not be less than.....per cent of the minimum of the specified tensile range of the plate used.

(*b*) Free Bend Ductility. The ductility requirement by the free-bend test method shall be not less than.....per cent.

(*c*) Soundness. The permissible total depth of all zones of defects on any plane parallel to the throat of the weld shall not exceed..... per cent of the specified weld throat dimension.

Defects are defined as gas pockets, slag inclusions, cracks and lack of fusion or root penetration exceeding.....in. in greatest dimension. Lack of soundness shall be evaluated by the total depth of all "zones of defects," measurements being made of such depths on a line or plane parallel to the throat of the weld. A "zone of defect" is defined as the area within two lines perpendicular to the throat of the weld and bounding any one defect, or any group of defects whose depths are overlapping. Illustrations of typical cases of "zones of defects" and the total depth of such zones are given in Fig. 22.

Part II

9. Test Results Required (Revised)

For any of the types of welds specified in Pars. 2 and 5, the permissible total depth of all zones of defects on any plane parallel to the throat of the weld shall not exceed the amount prescribed in Part I, Pars. 9 Ac, 9 Bc or 9 Cc.

* Experience indicates that a small amount of porosity is not as objectionable as other types of defects.

Design of Connections*

By H. C. WHITTLESEY†

THE design of connections is not only a consideration of the stresses involved, but must also include a close watch of the economy of the materials and the practicability of the assembly.

Stresses

The stresses used will depend upon whether the loading is static, dynamic or subject to impact. Tests have shown that loss of strength by fatigue shows up for a fluctuating load even though the stresses are not re-reversed. The greater the range between maximum and maximum stresses imposed the lower will be the ultimate strength.

For static loading the customary unit stresses on the weld throat are 11,300 lb. for shear, and 13,000 lb. for tension. The shear value is a convenient figure in that it transforms to 1000 lb. per inch per $^1/_8$ inch of fillet size. Thus, a $^3/_8$-inch fillet is good for 3000 lb. per inch, and there is no distinction made between end fillets and side fillets.

All the forces due to eccentricity must be included with the direct loads in determining the stress on the weld. Some types of eccentricity are shown in Details 1 to 6. The prying effect in Detail 1, of the moment about the longitudinal axis of a single weld is the worst possible position for a weld and should never be used. A combination with another weld that can develop a couple as in Detail 3 will relieve the prying effect. Again the bending in Detail 2 is bad, and should be corrected by extending the middle plate at least four times the plate thickness beyond the weld. If the plates are not in contact as in Detail 6, the prying effect again exists and is in proportion to the gap. Types 4 and 5 often are found in design and the stresses can be computed.

The allowable values have been established by tests on many sections and do not represent the actual stresses in the material. For end fillets as in Detail 3, it is very probable that the weld metal is stressed to twice the value of the parent metal. (1.41% for direction of resultant and 1.41% for reduction of throat area.) Mr. Priest has a nice summary of the various current theories on this point (Aug. 1933 issue JOURNAL AMERICAN WELDING SOCIETY). Photo-elastic studies have also shown a concentration of stress in the fillets which verify the theory to some extent.

For side fillet welds, theory and experiment have shown (A. S. C. E. 1934 Transactions, Page 409) that the ends of a weld may be stressed to more than twice the average value until relief is obtained by a stretch at the elastic limit. This is the same as has been found for a long line of rivets. As Mr. Priest points out, the stress curve flattens out as the elastic limit is reached and is therefore of no concern unless the joint is to carry impact or repeated stresses. At reversal of load the ends of the weld would again have to exceed their elastic limit and this would induce initial fatigue failure at the extreme ends followed by a progressive failure.

The recent publication of the AMERICAN WELDING SOCIETY on Specifications for Highway and Railway Bridges has tables of stresses for both base metal and weld areas when subjected to fluctuating loads. For fillet welds the formula is:

A = Max. $-{}^1/_2$ min./7200, but not less than Max./9600

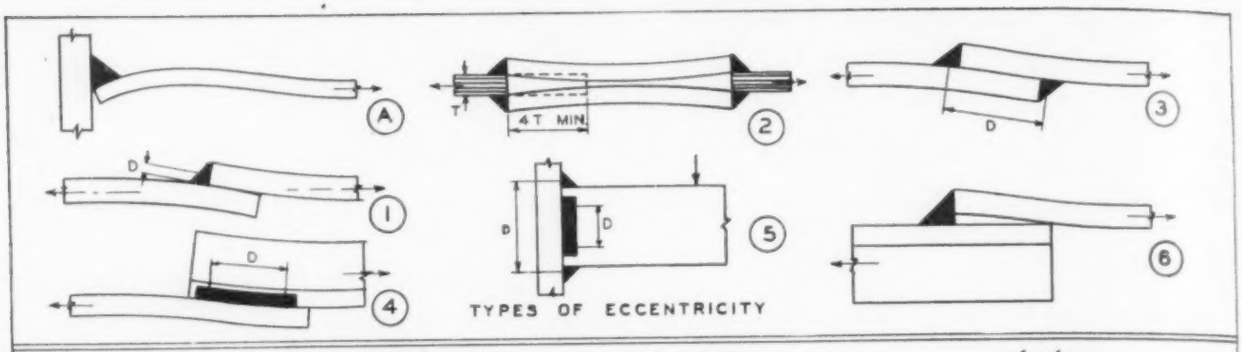
Thus, for a fillet weld subjected to complete reversal of loads, the design strength of a $^3/_8$ fillet would be only 960 pounds per linear inch of weld, or approximately one-third the value used for a static load. The butt weld is not penalized so heavily, only reducing to 50% of the static value for full reversal of load.

In the above specification in the Foreword makes this statement: "8. The evidence of repeated load tests is, unmistakably, that fillet welds are susceptible to fatigue failure at lower loads, or fewer repetitions, than butt welds. This is apparently because of the more sudden and pronounced kinking of the stress path. Whereas is has been customary to specify against butt welds because they are difficult to introduce without excessive shrinkage stresses, it is now incumbent on the designer to reconsider this preference, except the greater endurance value of butt welds, and arrange to employ them wherever the locked-in stresses can be controlled. This is only a special case of the general consideration, that in fatigue testing any sudden discontinuity of section and stress-path is a source of early failure. All designs must be detailed from the standpoint of having gradual rather than sudden transitions. A recommended detail which may be mentioned as illustrative, is the shaping of the end of an outer cover plate on a welded girder with a long symmetrical taper, so that the picking up of its stresses may be gradual and well distributed across the flange."

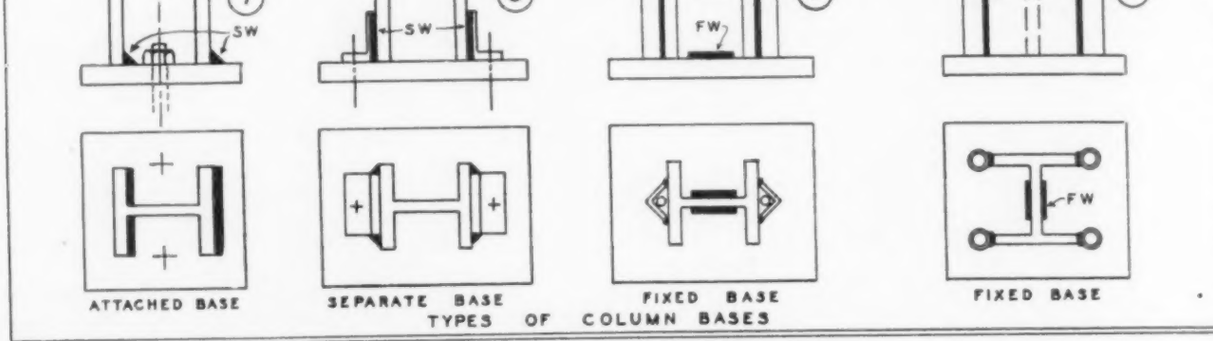
Mr. Jensen makes the very good recommendation that if the plates of a connection are overdesigned, it is advisable to overdesign the welded joint in order that the weld be not the weakest link.

Mr. Fish, page 139 of his book, Arc Welded Steel Frame Structures, has an explanation of the residual stresses in butt joints. The progressive shrinkage of the molten metal produces tension at the ends of the joint and corresponding compression through the center section. By gradually applying a load to the joint the elastic limit of the two ends will be reached first and the resulting yield will tend to equalize the stress. He also states that rapidly applied loads, especially impact, do not afford the time element necessary for yielding without increase of stress; theory indicates, and experience has confirmed beyond doubt, that suddenly applied tension is liable to crack the welds (even fillets) which have high residual stresses, whereas welds which are free or nearly free from initial stress withstand tension shock admirably. Mr. Fish then recommends, that we avoid resultant initial tension in a butt weld which is to be used to resist tensile stresses. Such a weld should be made only when one of the connected parts is a loose connection piece which has not yet been welded to any other part. He also states that butt welds, being more subject to residual stresses than fillet welds, should not be used for tension in bridge floors, or in any live load members of short-span bridges or in other framework subject to shock or sudden loading.

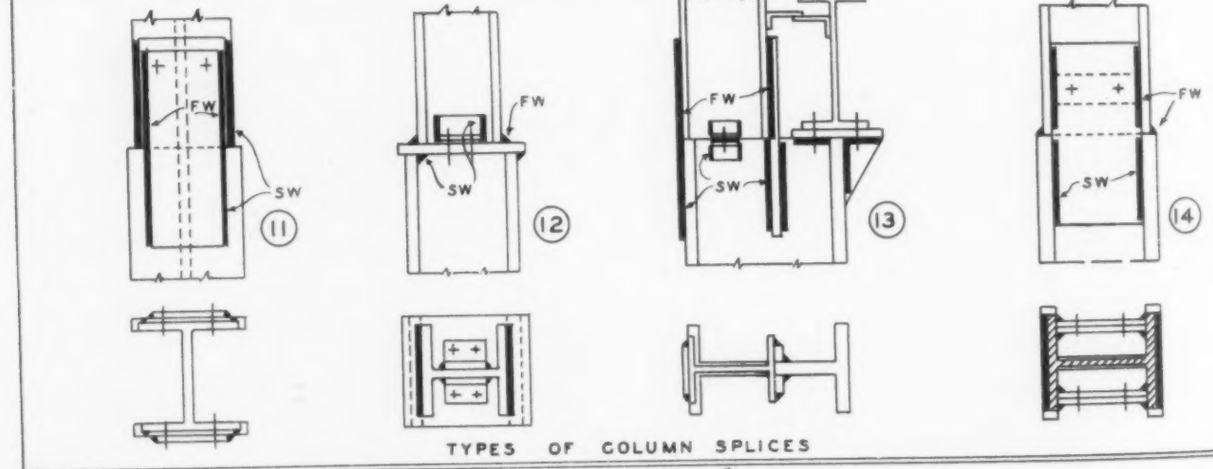
* Presented as Lecture No. 10 of Los Angeles Section Course.
† Structural Engineer.



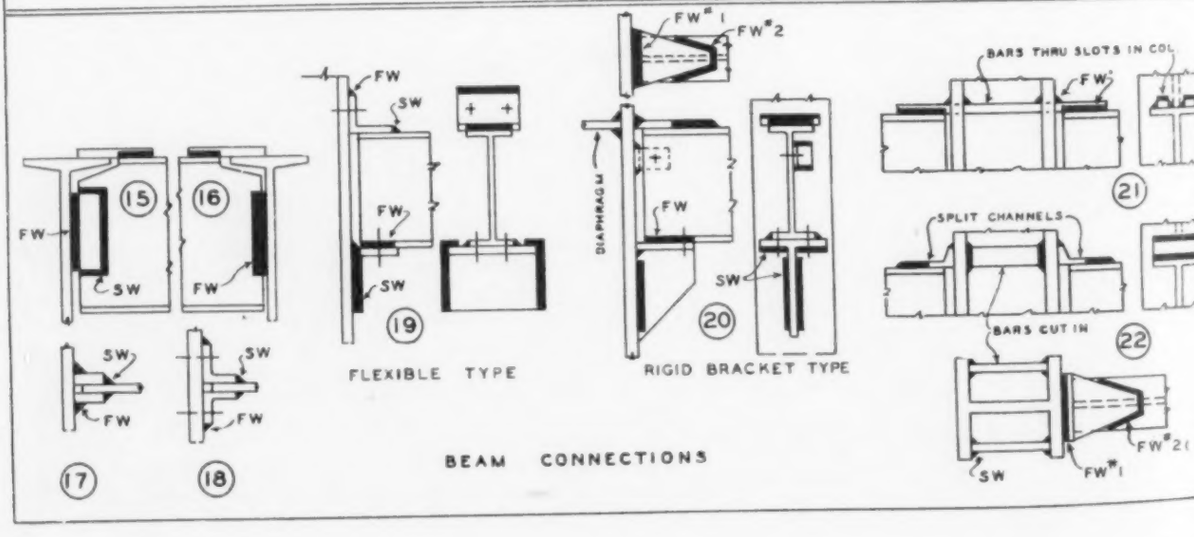
TYPES OF ECCENTRICITY



TYPES OF COLUMN BASES



TYPES OF COLUMN SPLICES



BEAM CONNECTIONS

Economy

In general, fillet welds require less preparation of the parts preparatory to welding than do the butt welds, because the parts may be lapped or butted together without the necessity of spending a great deal of time in beveling or preparing the plate edges. Furthermore, when the plates are lapped, the dimensions need not be held to close tolerances as is required for butt welds.

The choice in the size of a weld is an important consideration. Since the strength of a fillet weld is directly proportional to its size, and the volume is proportional to the square of the size, the smaller welds have greater strength for the amount of metal used. The $^3/_8$ fillet has more than twice the volume of a $^1/_4$-inch weld and yet has only 50% more strength. The $^1/_4$-inch weld is the smallest size generally used in structural work, and the $^3/_8$ is the largest fillet considered feasible to place in one pass by hand. Cost cannot always control the size, however. Some members may require an intermittent weld to avoid warping, and others require a continuous weld to seal the joint. With butt welds there is no choice of size, except to vary the plate size. Also with fillet welds, the size is often required to be the same dimension as the edge of the plate.

In all field work provision must be made to hold the members together before welding. Clamps have been tried, but field bolts seem the most satisfactory method. The beam to column bolted connections should have enough stiffness to brace the frame without a large amount of rope ties. Some patented methods of lugs and clips that do away with the field bolts have been tried. One method is described in the January 1935, WELDING JOURNAL, page 15.

In the cross bracing, between roof trusses, it is desirable to have bolts for the field connections to permit welding to follow the erection fitup. Generally one additional bolt at a connection will be sufficient for small trusses, and will eliminate the field weld for these members.

In general, the shop punching of members should be limited to the smaller pieces to avoid handling charges. Considerable cost is saved when all holes are eliminated from the larger pieces.

The book by Mr. Fish has an excellent chapter on the economy of welds.

Column Bases

Detail 7 is for small columns when the base can be attached to the section in the shop. The fillets are both on the right hand side of the flanges so that the column need not be rotated to get both welds.

Detail 8 is a good connection for columns requiring the base to be grouted in place before the column is erected. It is not a rigid type.

Detail 9 is for a separate base and fixes the column in one direction. The field weld on the web should be added for shear since the bolts do not fit tight in the angles.

Detail 10 consists of short sections of heavy pipe welded to the four outstanding legs of the column. Washers are required under the bolts as in 9, and field welds should be added on the web or flanges to prevent creep. This detail can be made to fix the columns in both directions and is well suited for mill building with crane rails.

A simple column base with a fixed condition can be made by placing the angles in Detail 8 on the web and then field welding around the toe of each flange with a fillet sufficient to fix the column. It would be well to place only half of the welding at each toe at a time to reduce the effect of shrinkage stresses.

Column Splices

For erection purposes it is necessary to provide bolts to hold the column sections together until the welding can be completed. Some ingenuity can be exercised to keep the bolt holes in the small pieces and the main members free from punching.

Detail 11 is a simple flange splice, particularly suited for constant dimension shapes. If filler plates are required they can be shop welded to the upper section. The field bolts shown through the column shaft might well be replaced with a pair of web angles as in Detail 13.

Detail 12 is a practical butt plate splice. The amount of welding shown can be easily increased to both sides of the flanges if considerable tension is anticipated.

Detail 13 is a typical crane column splice and suitable for a large bending stress. Many variations are equally feasible.

Detail 14 avoids the bolt holes in the main sections but requires considerably more feet of welding.

Beam Connections

Beam connections are of two general types, depending upon the amount of end restraint provided for. In all types of connections there are bending moments to resist, as well as the direct stresses, and the general rule is to use the resultant of the combined stresses to design the weld area. Figure 12 of Mr. Priest's article is a convenient chart for solving these problems.

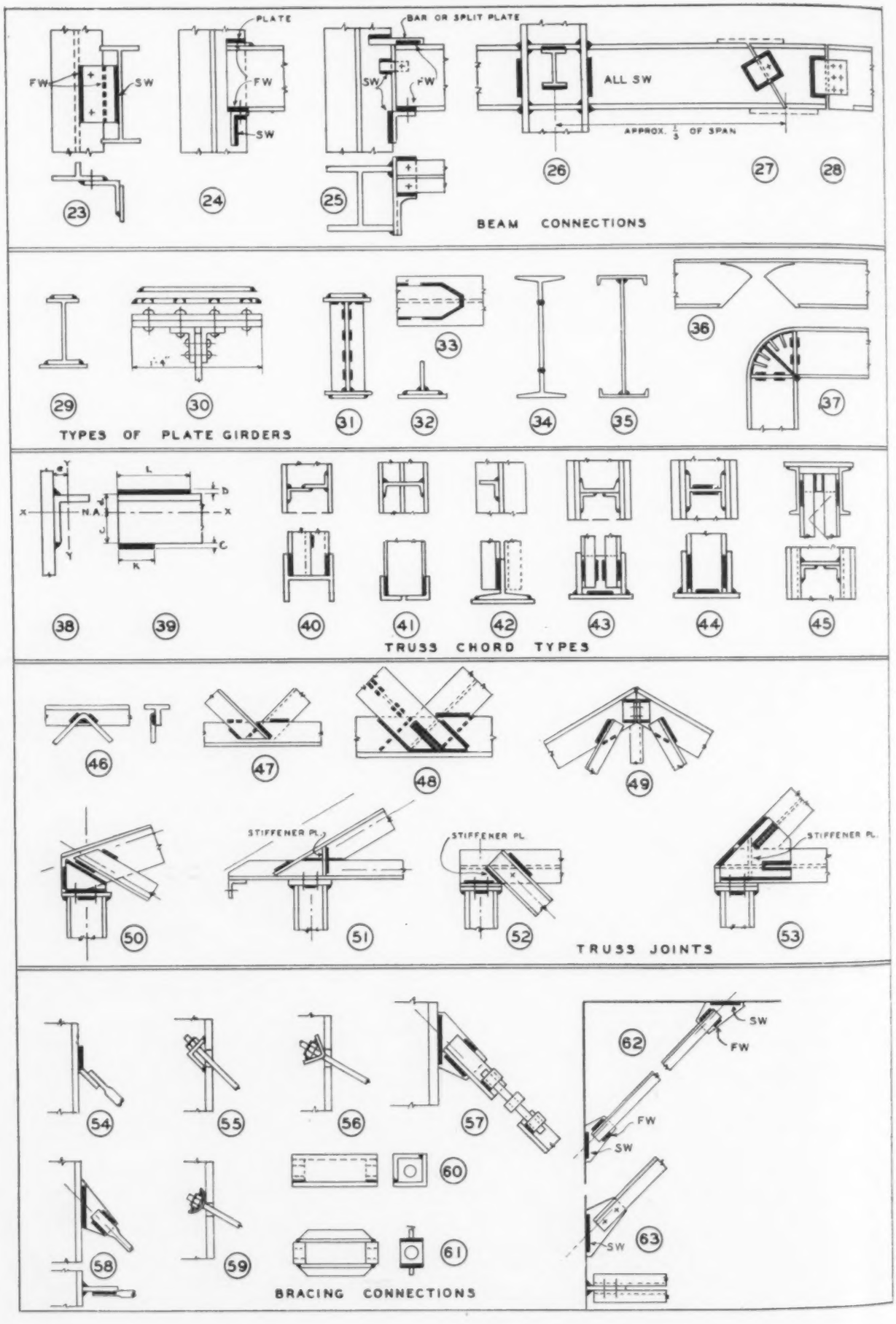
Detail 16 shows the simple web connections. Mr. Fish gives a very good discussion of the danger of not providing for end rotation in this type. He states that it should only be used at a flexible support and should be designed with sufficient weld to deform the beam web as deflection occurs. To obtain this strength, the A. W. S. Bridge Specifications state that the net size of the weld on each side should be not less than $^4/_5$ of the web thickness and the length of weld not over $^2/_3$ the beam depth. This connection is only suited to intermediate beams and Mr. Fish states that it is questionable whether joints of this type are advisable in bridge floors where the repeated dynamic loading would be likely to induce fatigue.

When using the direct web connection, it is necessary to have the opposite end of the beam adjustable as shown in Details 17 and 18. Detail 18 is a more flexible type and is preferable for both ends of the beam. The field bolts need not be provided if a flush plate be arranged for a seat as in Detail 15. Mr. Priest does not like the connection of Detail 18 because of the prying effect on the field welds when the angles deflect slightly. He recommends permanent erection bolts to hold the angles tight to the support. Both the field welds and shop welds have a moment as well as a direct stress to resist, and the resultant of these two determine the amount of weld. Mr. Priest has provided a convenient chart that solves the summation of stresses for both welds.

Detail 19 shows the flexible type of seat angle connection. There has been considerable discussion and experimental work about this type of support and agreement of method of analysis had not been reached. One point of difference is how far out on the seat should the load be considered to act and the other difference is where should the neutral axis of the vertical welds be located.

Mr. Lawson in the June 1935, JOURNAL shows curves for solving the size of angle and amount of welding based on a neutral axis considerably below the midpoint of welds. The lever arm to center of pressure is about the same as Mr. Priest uses.

Mr. Fish recommends that the angle seat be shimmed with No. 24 gage metal out from the column face and a


FW
SW
PLATE
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BAR OR SPLIT PLATE
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ALL SW
APPROX. 1/3 OF SPAN
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BEAM CONNECTIONS
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TYPES OF PLATE GIRDERS
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TRUSS CHORD TYPES
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STIFFENER PL.
STIFFENER PL.
STIFFENER PL.
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TRUSS JOINTS
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BRACING CONNECTIONS
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bottom weld be used for short side welds. For a lever arm he takes the maximum of three conditions: (1) Crushing strength for contact area. (2) Compression in web. (3) Web buckling. Tables are given for selecting the maximum required length of bearing.

In an investigation by Lyse and Schreiner published in the JOURNAL of February 1935, they recommend that the load be considered as concentrated at the end of the beam with zero bearing area. This short lever arm favors the design of the angle. Their recommendation is to design the side welds for shear only when the angle is not overloaded as a cantilever.

Mr. Priest has a reasonable method of analysis with charts to assist in a quick solution. These are included in the article referred to above. He determines the lever arm on the A. I. S. C. formula for web crippling. The charts give the length of weld and thickness of angle. He makes the recommendation that the side welds be continued around the top end of the angles a distance of $^1/_2$ inch. This part of the weld is not included in the calculations, but is at the point of maximum stress and where experiments show the first rupture to take place.

Detail 20 shows a rigid type of bracket. Mr. Priest recommends this detail for all reactions over 35 kips. The bracket may be a split beam or two plates forming a tee. In his design charts for this type of connection, each of the outstanding welds is assumed to be one-fifth the length of the vertical weld.

The top connection of Details 19 and 20 are a separate consideration and determine the degree of restraint of the beam. In a report by Lyse and Gibson in the JOURNAL, October 1936, tests are described for top angles and top plates welded to the face of the column. Some of their remarks and conclusions are as follows:

"For the plate specimens—much difficulty was encountered in welding to the vertical face because of the magnetic blow. A satisfactory fillet weld could be made but the quality of a single V butt weld was very uncertain. It was practically impossible to secure fusion within $^1/_8$ inch of the root of the butt and it was very difficult to keep slag pockets from forming in the upper part of the weld."

Speaking of vertical side welds on the angles: (Not shown)

"The concentration of stress at the end of the side weld, the uncertainty of strength, and the small flexibility seem to indicate that this type of weld is undesirable."

Speaking of the weld along the top of the angle:

"Increased thickness of the angle increased the stiffness and strength of the angle to a very marked extent, while the flexibility is still maintained."

Speaking of the top plate butt welded to the column face:

"When fairly good fusion was secured in the butt welds, the failure occurred in the face plate which represents the face of the column. It seems that heat produced by welding destroyed the structure of the metal in the face plates and caused grain growth which weakened the metal to such an extent that chunks up to $^3/_8$ inch deep were torn from the plate."

Speaking of the fillet welds on top plate: (See Detail A)

"It was decided to measure the initial welding stresses, and it was found that for plates thicker than $^1/_2$ inch the surface stress exceeded the yield point of the material and caused a decided upward bow in the plate." (This would be equivalent to the prying effect in Detail A.)

Speaking of top plates in general:

So many difficulties and uncertainties were encountered in this study of welded plates, that they do not seem suitable for stiff beam connections where they must be depended upon to take the fixed end moments.

From the experimental work of Hollister and Gelman, reported in the JOURNAL, October 1932, it is evident that a tapered plate as shown at the top of the beam in Detail 20 is far superior to a weld straight across the beam. The tapered plate distributes the load over the members in nearly a uniform value without concentration of lines of stress as in the other types.

In another reference I cannot now locate, the author stated that it is never a good policy to make a weld directly across the face of a highly stressed member. If it is true that there is any change in the base metal due to welding it is quite evident that the above remark is sound and it would be better, therefore, to taper point the ends of all cover plates and connection angles on important members.

The web connection angle in Detail 20 is recommended for erection purposes. A diaphragm is also shown as a reminder that the stress transferred to the column face has to be taken out again on the other side.

Detail 21 has many possibilities and overcomes some of the faults of other connections. Two long straps are inserted in the holes in the column flanges and are welded to the top of the beam flanges. The holes in the column can be welded up to regain the column strength but generally the column shaft is overdesigned at this point of support and the holes may be left partly open. A variation of this detail might also be used at the bottom support of the beam, with possibly a web connection for vertical shear.

Detail 22 suggests the use of a split channel to increase the value of the top angle shown in Detail 19. It also shows the use of bars at the outer edges of the column flanges in place of the web diaphragm more generally used. Note that the column fillet is shown placed first and the beam weld placed second. The same order is shown in Detail 20 for the field welds.

Detail 23 shows an offset bracket consisting of a single angle. The polar moment of the area of the welds against the column is used to determine the maximum bending stress which is to be added to the simple shear stress. Mr. Fish has an excellent table for solving the resultant maximum stress of combined bending with direct loads.

Detail 24 is a suggestion for beam connection framing between the flanges of a column. The connection can be made fairly stiff and has the advantage that the bending moments are not resisted by the welds taking vertical shear.

Detail 25 is probably a spandrel beam seat. The lower connection as shown is not much good for wind bracing moments. The seat angle has been coped to clear the fireproofing of the column.

Detail 26 is shown in the Lincoln Electric Company Procedure Handbook. The idea is to fully weld the beams to the columns in the shop and make the field splice in mid span near the $^1/_5$ point. The welding can be kept to a minimum, since butt welds are feasible and no end clearance is required. The mid-span splice is shown in two ways. Detail 27, cut on the diagonal, is intended to facilitate erection. The double splice plate has only one bolt hole and is intended for field welding. Detail 28 requires the lower flange to be coped if both splice plates are welded in the shop. The field side might re-

main bolted as shown. This arrangement would not be suited to tall buildings, where the wind moments are large, nor to unbalanced spans. This could be remedied by adding a flange splice top and bottom of the beam. This would also add greatly to the stiffness of the column in its tendency to rotate. The small amount of field welding is attractive.

Plate Girders

The A. W. S. Bridge Specifications states, "Girders shall be proportioned by their moments of inertia and their webs shall be fully spliced. Stiffeners may be either shapes or plates, welded at their end on the compression flange by continuous welds and to the web by continuous or intermittent welds, designed to transmit the stresses. Ends of stiffeners shall be welded to the tension flanges only when necessary for bearing in which case transverse welds shall be avoided by the use of fills or pads."

This last statement is in keeping with the general policy of avoiding welds directly across the face of a highly stressed member.

The welds connecting the web to the flanges are calculated by the same method as used for flange rivets. At any point of a simple span the vertical shear divided by the depth of web plate is the approximate shear per inch to be transferred to the flange plates. Mr. Fish has a convenient table in his book for selecting the size of an intermittent fillet weld for static loads.

Where cover plates are used, the McClintic-Marshall Corporation Standards state:

"Cover plates are extended beyond the theoretical length a sufficient distance to permit continuous welding to connect for the proportions of stress in the covers. It is assumed that the stress in the girder flange without covers is the full permissible stress and that the covers will take a share of the stress based on the ratio of section modulus without covers to the section modulus with covers. Between the ends tack welds are used. The total of all the welding between the end of the cover and any point should develop all the stress at that point. The minimum length of weld should be about eight times the weld size and the maximum clear distance between welds not more than 24 times the thinnest plate for tension flange nor 16 times the thinnest plate for the compression flange."

Mr. Fish states that the width of a compression flange or cover plate should not exceed 30 times its thickness.

It is uneconomical to use more than one cover plate on a flange for the reason that each succeeding joint has to carry all of the load of the outer plates, and the same stress is thereby carried twice through welds.

Detail 29 represents a beam strengthened with plates welded top and bottom. The lower plate is made wider than the top plate to facilitate all down hand welding. The amount of welding would be as outlined for plate girders.

Detail 30 shows a riveted girder strengthened by adding cover plates to the flange. The first plate is punched to fit over the projecting rivets with plug welding around each rivet head. The second plate has been added for looks more than economy.

Detail 31 is a typical built up girder with one cover plate. The stiffeners are not welded at the lower flange as required by the Bridge Specifications. In Detail 32, an alternate lower flange is shown that will allow the cover plate to be welded on without turning the girder over. Detail 33 shows the correct termination of the cover plates. This obviously cannot be used with Detail 32.

Detail 34 and 35 show some variations that may be used for special purposes.

Details 36 and 37 show possibilities for making up rigid frames. The outer flange is not cut and is folded around the trimmed web as a templet. The cut flange and web must be butt welded and plenty of stiffeners added. The small stiffeners shown are brackets welded on to keep the outer flange from collapsing on the curve. This detail looks nice, but costs a lot of money to build.

Trusses

The greatest field for economy of welded structures over riveted structures seems to be in truss design. The principal savings are in the use of the gross sections for tension members and in the elimination or reduction of gusset plates.

The standard practice for attaching an unsymmetrical shape such as an angle, is shown in Details 38 and 39. The object is to eliminate eccentricity by making the neutral axis of the welds coincide with the neutral axis of the shape. The total amount of weld required is distributed so that KcC is equal to LdD. Mr. Vogel in the June 1936 JOURNAL has a table giving lengths of K and L for various sizes, of angles. Tests have not shown that this method is entirely justified and, therefore, there is no need of great refinement in determining the distribution of weld area.

The eccentricity "e" of the outstanding leg has the same effect as in riveted joints and is allowed for in the same way. Some designers use a net section equal to the connected leg plus 50% of the outstanding leg while others use an arbitrary factor of 60 to 80% for all sizes of angles.

Details 40 to 45 are some of the standard types of truss chords. Detail 40 shows an "H" cord with overlapping angles for web members. Detail 41 has channel web members and two angles for the chord. Detail 42 is a split beam chord with single angles attached to the stem on alternate sides. Details 43, 44, 45 have a built up box section for the chords. This may be justified for some reasons, but off hand looks like a lot of extra welding to build the box.

Details 46 to 53 show truss joints. Detail 46 is the simplest and represents the top chord of a trussed rafter with a continuous round bar for web members. Detail 47 shows angles staggered on opposite sides of a tee shaped chord. Detail 48 is a heavy connection without gusset plates. The one web member is an "H" section and the other, the outside piece, is an "H" section built up of three plates welded together. Some of the welds look like they would be difficult to place. Detail 49 is the peak of a roof truss designed for a field connection. The pair of angles act as a web splice and also for erection bolts.

Details 50 to 53 are heel connections, and call attention to stiffener plates required in many such joints. In 52 the stiffener is called for but not actually shown. Details 50 and 51 are of the split beam type, and the next two are of the "H" section type. Details 53 is a good example of a heavy joint with a compact gusset arrangement utilizing the double fillet in a wide slot. The latest specifications do not permit the slot to be filled, and only follow an overlap at the toe of the fillets of one-fourth the fillet size. Plug welds are never recognized for strength in structural work unless the hole is large and the fillet's shape is retained around the inside of the hole.

Bracing Details

Detail 54 is often found in practice and is bad. The high concentrated stress at the heel of the weld is likely to start a progressive failure. Detail 58 accomplishes the same connection with no more welding and without any

eccentricity or tendency to tear off. The gusset plate could have been slotted to receive the rod in place of flattening the end of the rod.

Detail 55 is a good method of attaching a rod to a web member. Details 56 and 59 are about the same, but cannot be adjusted at the nut as can be done in Detail 55.

Details 60 and 61 are turn buckles made up of square nuts, and shapes. In 60 there should be holes punched in the side pieces to allow a view of the end of the rods for proper adjustment.

Detail 57 is an adjustable angle brace which may have some usefulness. The sketch is self explanatory.

In all bracing details, the welding must be so scheduled that all butt welds and end fillet welds can shrink freely without setting up residual stresses. Thus, in Detail 62, the end fillets should be placed first, connecting the gusset plates to the flame, and the side fillets on the angles placed last.

One of the important functions of bracing is to pull the main members into line by precalculated location of bolt holes. This is an action that the fully welded bracing has lost, and will be greatly missed in the field by the erection crews. The use of field bolts and shop welding as shown in Detail 63 is a reasonable compromise and may save a difficult set-up for the welding crew.

Now that the quality of the weld metal developed to the point of equaling the base metal in strength and ductility, more attention can be focused on the two important faults, shrinkage and fatigue. The new specifications recognize these "ghosts" and endeavor to make broad rulings to cope with them. If the designer will keep in mind that fatigue is to be guarded against by the right selection of the design stress and that shrinkage can be minimized by the order of placing the weld metal, then the good natured coated rods will have a chance to adjust themselves to our theories.

Some Effects of Welding on Ship Construction

By JAMES B. HUNTER*

SHIPBUILDING practice has undergone many changes in the last decade. Many new materials have been introduced bringing with them the need for new methods, but without doubt the introduction and general adoption of welding have had more far-reaching effects than any other one innovation.

Since the earliest days of iron ships the rivet, whether driven by hand or power, has been the accepted method of fastening together the component parts of a ship's structure, so it is not surprising that a new method should entail many changes in shipyard procedure.

The *Transactions* of this and other technical societies contain many excellent papers on welding practice and technique and the excellent paper by Messrs. Hudson and Jackson describes another important development in the art.

This paper is intended to describe briefly some of the effects observed in shipyard practice and methods due to the substitution of welding for riveting; it is hoped that this attempt to gather together such effects may prove of interest to the members.

It appears that the subject might best be subdivided into the following groups: Design, mold loft and fabricating shop, erection and fabrication, outfitting and completion, summary.

Design

The elimination of faying flanges and laps is of course the most obvious effect and is probably the greatest single weight-saving factor. However, it should be borne in mind that the flanges did provide certain stiffening effects and the panel size is in effect greater with welded stiffeners at the same spacing. On the other hand the elimination of rivet holes in shell and deck connections, for example, gives an approach to 100 per cent strength through a frame line in place of a value of approximately 85 per cent usual with riveting. Some revision of methods for standard strength calculations would appear to be in order, particularly where longitudinal framing is concerned and when comparisons are being made between welded and riveted connections. Care should be used in selection of materials, particularly as regards certain of the high-carbon steels which may be attractive because of higher legend physical characteristics, since these qualities may diasppear as a result of welding.

In the race for weight saving built-up sections have come into common use for stiffeners because of the lack of rolled sections designed for welding. These sections entail greater labor both as to design and fabrication and it is to be hoped that new sections will shortly be available. The need is obvious but agreement as to detail is difficult. Inherently such sections should be designed to provide variations in section modulus with the minimum of waste.

Welding has produced a new type of structural plan due to the disappearance of flanges and in some cases laps. This, of course, leads to simplification, but the need of specifying welding in greater detail than is usual with riveted structures somewhat offsets this.

In order to produce proper drawings it is necessary that a working knowledge of welding practice be obtained by the draftsman since sequence of welding and assembly plays an important part in avoidance of so-called built-in stresses so far as practicable.

One other point in design appears worthy of note; namely, the rigidity of the structure due to the elimination of slippage inherent in riveted joints. In a structure subject to such variation in loading and stress as a ship's hull, this appears to the writer to call for caution in the adoption of welding for the primary strength members, because of the impossibility of relieving any stress in such members after assembly.

It should be borne in mind that a ship's hull is the most intricate and among the largest pieces of structure to be assembled without annealing.

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The need of modification of design to enable the maximum amount of prefabrication on the ground or in the shop before erection is evident. This is apparently beginning to receive the attention it deserves. If this is carried to its logical conclusion, then it is possible to visualize the future ship made up of a series of prefabricated units all ground assembled with only the joints between units left to be made actually on the ship.

While the foregoing outlines the principal changes due to arc welding on the basic hull design, many other parts of the vessel are radically affected. Mention should be made of the virtual disappearance of anglesmith work and staples. Instead of elaborate angle staples box-ended and fitted painstakingly around bulbs or flanges, we have today a mitered joint welded together or a simple plate staple welded in place and generally without the use of shims or "dutchmen."

Rigging and deckfittings, formerly involving the use of intricate forgings, can often be replaced by simple welded parts and today the use of welded bitts and chocks is becoming commonplace, replacing castings. Stems are being fitted of built-up design and even in stern frames castings are being replaced by weldments. Some of the latter involve the heaviest type of welds and are given careful annealing.

Piping, tanks and valve manifolds, with the necessary elbows and tees, are largely welded on certain classes of vessels, as are hatch, door and airport fittings, boat davits and stacks.

Among the major machinery parts affected, reduction gear and turbine casings are now often made up of a combination of small castings or forgings and plate, particularly when weight saving is important and design is not standardized. Welded shells for condensers and other heat-transfer equipment have largely replaced castings. Boiler drums to meet the higher pressures and temperatures called for today would hardly be possible without resort to welding.

Mold Loft and Steel Mill

In the mold loft, of course, no difference is noted in the original laying down and fairing but the types of molds are changing.

Those for welded construction show only holes necessary for assembly but they must be marked for registration with adjacent members in addition to bevel cutting on the edges where required. Indicating position and size of welds is common practice in some yards, though not in all.

The omission of connecting members, such as clips, etc., calls for much greater care in making templates so that the close fit, so desirable for good welding, may result.

Many yards are today, particularly on the lighter structures, marking templates to show the sequence of welding and erection.

In addition to the individual templates it has been found of advantage to prepare an over-all mold for use with prefabricated units to ensure correct outline after assembly and welding.

Steel mill and fabricating shop methods have been very definitely affected by the introduction of welded construction. Laying out now means few holes but more marking to take care of accurate outlines and in many cases location of welds, etc. Check marks are necessary for registration, using waterlines, buttocks, etc., to locate pieces properly in erection. The use of built-up sections for stiffeners means, in many cases, straightening after welding and very often double layout, one for individual pieces, another for over-all.

Present practice indicates the advantage of more assembly in the shop and, if shrinkage is taken into account, more material lifted from the ship.

These considerations indicate certain definite changes in shop layout and equipment. Elaborate punch tables and high-speed punches are hardly justified but more and better planing equipment is needed. Much greater assembly space is necessary and this should be of the table or platen type rather than the open skids used for shop riveting. Carriage or portable types of machines for drilling and countersinking appear better adapted to this type of work than elaborate fixed machines. Accurate mechanically controlled flame-cutting equipment is a necessity, if costly hand cutting is to be avoided; if production work is of large volume, machine welding with some form of table appears desirable. Some change in furnace equipment also is required to take full advantage of the use of cutting and welding for forming plates, which otherwise would require severe furnace work.

Erection and Assembly

Erection and assembly procedure has been greatly modified by the use of welding, due primarily to the omission of holes and flanges for fastening individual members together and also because of the various methods adopted to take care of shrinkage and buckling particularly on the lighter structures.

The erection of a welded structure requires various attachments for lifting. These include pads and clips and in many cases additional temporary stiffening to take care of free edges. Shipfitters, burners and tack welders must be available because of the closer clearances and the need of positioning on datum lines rather than by registration and fastening by holes and bolts. After welding is completed, all temporary clips, etc., must be removed. The advantages of greater ground assembly can of course be obtained only if the crane capacities are large enough to handle the units so assembled, so that for any given yard a balance must be struck between the two for greatest economy.

In assembly, welding in most cases requires greater time due to sequence in order to avoid distortion and the introduction of so-called locked-up stresses. Such sequence usually entails the practical completion of one section before starting work on the adjacent section. This, of course, is in decided contrast to the picture with riveted construction, when riveting gangs can be worked all over the ship simultaneously.

This particular requirement entails a definite control on production all the way down the line from the drawings to the finished material. In order that it be successfully carried through, complete knowledge of auxiliaries, machinery etc., which entail substantial foundations and attachments to the structures, should be available at a much earlier date than is necessary with riveting or the erection will extend over a much greater period of time.

The greater amount of erection time also directly affects shipyard capacity and of course time of delivery. In the final analysis this may lead to a change in the relationship between shop equipment and the number of building berths.

Outfitting and Completion

While the popular conception of welding is apt to visualize only the effect on the ship's structure, the history of the application of welding to shipbuilding shows that its first uses were in making attachments of

fittings and for the building up and reclamation of worn or badly fitted parts.

Today there are relatively few vessels completed without some welding being used, and the list of uses embraces practically all types of attachments and all kinds of material.

In the manufacture and installation of the hundred and one details that go to complete a vessel today, welding is not confined to the use of the electric arc but other forms of weld such as the atomic and spot weld are in common use.

Welding has largely replaced other means of fastening hangers and clips of all kinds, also small foundations and seatings; in this field it offers definite advantages both as to time and cost, provided the necessary equipment is available.

Power leads and controls are needed on both building berths and outfitting basins. Special precautions against fire are advisable and different types of mechanics are required.

In testing, it will, I believe, be generally found that while leaks are fewer with welded construction their correction will be more costly since it may be necessary to empty a tank to replace a section of defective weld.

The two shops most affected by the use of welding are the sheet metal and pipe shops, particularly the former. The manufacture of small tanks, ladders, wash troughs, metal floor coverings, lockers, dressers, sheet metal doors, sheathing over insulation, metal tables, airport screens and scoops, dresser and counter tops, and the installation of the never ending label plates, to mention only a few items, have been modified until today, particularly in yards engaged on Navy work, one is apt to hunt around for the rivet bin after stumbling over a battery of spot welding machines and being warned off from enclosures devoted to arc and atomic welding.

Piping is today often welded on vessels and valve manifolds, headers, etc., are built to suit the particular need by welding rather than casting.

Even the shipwrights have not escaped the ever-present welders, as is shown by their work on rail stanchions, booms, side ladder stowage and, perhaps most interesting of all, the fastening of wood decks by means of studs resistance welded to the steel deck.

Supports for joiner work are today largely of metal welded in place, while joiner doors, trim and furniture metal are fabricated by means of welding.

Summary and Conclusions

Different types of vessels require different methods and shop equipment. It is evident that the simple box-shaped barge can be built with a minimum of equipment and tools; in this type of vessel welding entails the smallest initial outlay. However, as soon as we consider larger shipshape vessels changes in equipment and methods become of increasing importance; if welding takes the place of riveting in the major portions of the structure, definite modifications of shipyard practice appear inevitable.

We have already seen the development of the building cradle in its various forms, the use of large preassembled units and special assembly methods based on the use of automatic machines with tilting tables or other devices. Many designs have been produced having in mind ease of assembly and production and many different types of assembly clips and attachments.

Conclusions are dangerous and difficult, but, at the risk of making controversial statements, it appears to the author that so far the advantages of welding have been greatest in the case of small vessels, particularly those subject to damage against docks, as it has been demonstrated that fewer leaks develop and this is a particularly important point for small vessels engaged in oil deliveries. The trend in vessels of this type appears to be definitely towards welding the tank spaces completely, leaving the more complicated ends still riveted. This solution appears rational, since the additional cost and time are justified by the reduced loss of operating time and cost of upkeep.

In the larger merchant vessels welded bulkheads, both transverse and longitudinal, also major parts of the framing and small decks and flats, are being generally welded. These members can be largely ground assembled, leaving comparatively little ship welding, and the weight saving will probably justify whatever extra cost is involved. Units, such as bulkheads, also lend themselves to production methods using automatic machines with special assembly methods, although the first cost of such special fixtures must be justified by reduction in cost of the finishd unit produced.

The welding of shell and strength decks on larger merchant vessels introduces major problems both as to design and manufacture, and it appears difficult to justify the greater cost and time involved in this. Some weight saving is possible but the difficulties of assembly are serious and the cost increase large.

Welding has advanced recently to a great degree in the building of naval vessels, but in the design of this type the urge to save weight, because of treaty limitations, justifies increased cost, since military characteristics can be provided which would otherwise be impossible. Such reasoning, however, cannot be applied to merchant vessels except in very special cases.

While it is impossible in a brief note such as this to cover with any degree of completeness so important a subject and while it is fully realized that methods and procedure used in one shipyard may not apply to others, nevertheless it appears to the author that ultimately yard equipment for welded construction will become as similar in yards producing the same type of ships as did equipment for building riveted vessels. We are still feeling our way in this and while undoubtedly in some cases welding has been undertaken where it cannot be justified by economic considerations it will ultimately find its true place in the building of that inherently complex structure—a ship.

Time Control Solves Spot Welding Problems

By H. THOMASSON†

THE successful spot welding of the non-ferrous group of metals, particularly in dissimilar combinations is usually considered to be difficult if not impossible of practical solution. The ignitron spot welding timer with its absolutely accurate control of the current times make combinations such as 18-8 stainless to nickel silver, bronze to mild steel, or galvanized iron, brass to bronze or nickel silver and many others a simple matter while such metals as aluminum, lead and zinc are readily spot welded to themselves.

Using "Cupaloy" a copper-chromium alloy as welding point material in a 100-kva. press type welder which has a 12-inch depth of throat the metals and combinations shown in the two tables attached were all successfully spot welded in a single six-hour developmental period. Point diameter was carefully held to one-quarter inch while the currents used were 60 cycles with a 440-volt primary. The pressures given were obtained by means of a pressure meter. The tables show the metal or combination of metals together with the number of cycles applied, the percentage of the machine capacity used and the point pressure.

Each sample was tested as made and no weld was considered as accomplished until the spot produced had first class appearance, free from burrs, feathers or serious discoloration or indentation and which on a test to destruction pulled a hole in the parent stock at least $^3/_{16}$ inch in diameter.

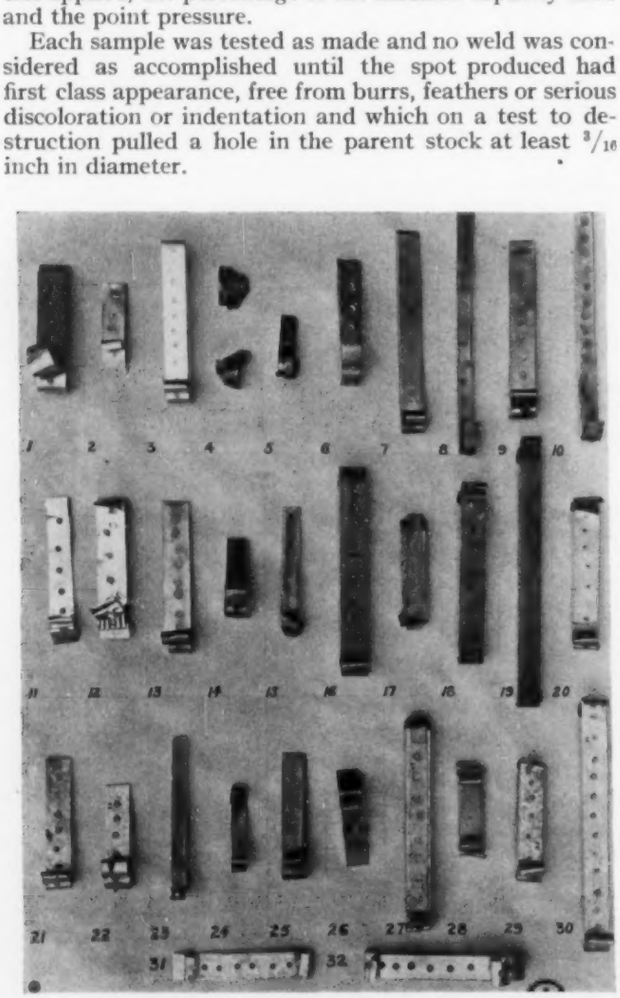


Fig. 1—Samples Welded with the Ignitron Spot Welding Timer. (Sample number corresponds with numbers in the tabulations.)

†Welding Engineer, Canadian Westinghouse Company, Ltd.

It was, however, found to be impractical to get a spot in the $^1/_8$-inch thick zinc which would tear the hole due no doubt to the fact that the thickness was such as to make the circumferential cross section around the spot greater than the area of the weld and the same was true of the everdur. The zinc was the only one in which the indentation was at all serious running about 30% of the thickness. In no other case did this amount to more than 10%.

The samples were later laid out and photographed with results as shown in Fig. 1, the number of the sample being given in each table.

Table 1—Metals Welded to the Same Material and Thickness

	Metal	No. of Cycles Applied	Percentage of Machine Capacity Used	Tip Pressure in Pounds	Sample Number
0.025	Aluminum	1	63	400	2
0.0625	Aluminum	3	75	400	3
0.125	Aluminum	5	88	400	1
0.020	Sheet lead	1	7	125	4
0.0625	Sheet lead	1	18	200	5
0.125	Sheet zinc	5	80	300	6
0.050	Sheet brass	4	57	500	9 & 10
0.0625	Sheet brass	4	80	500	7 & 8
0.032	Nickel silver	2	18	400	23
0.032	18–8 stainless	1	7	650	20
0.093	Tinned Everdur	5	57	500	14
No. 26	Gage gal. iron	2	57	450	21
No. 20	Gage gal. iron	2	62	500	22
0.010	Tinned sheet iron	2	70	470	11
0.010	Tinned sheet iron (three pcs., centre one corrugated)	2	88	470	12
0.040	Sheet steel	3	7	470	18
0.050	Sheet steel	3	7	470	16
0.0625	Sheet steel	3	13	470	19

Table 2—Metals Spot Welded to Other Metals and Thicknesses

	Metal	No. of Cycles Applied	Percentage of Machine Capacity Used	Tip Pressure in Pounds	Sample Number
0.050	Brass to 0.050 Olympic bronze	4	57	450	15
0.062	Brass to 0.062 Olympic bronze	4	63	500	13
0.050	Brass to 0.0325 nickel silver	3	57	450	24
0.050	Olympic bronze to 0.032 stainless steel (18–8)	2	18	550	26
0.050	Olympic bronze to No. 20 gage galv. iron	4	67	500	27
0.050	Olympic bronze to 0.050 sheet steel	2	32	470	25
0.032	Nickel silver to 0.032 stainless steel (18–8)	2	7	450	17
No. 26	Gage galv. iron to 0.010 tinned sheet steel	2	57	400	31
No. 20	Gage galv. iron to 0.040 sheet steel	3	13	400	30
No. 26	Gage galv. iron to 0.032 stainless (18–8)	2	31	550	29
0.040	Sheet steel to 0.032 stainless steel (18–8)	2	13	550	28
No. 20	Gage galv. iron to 0.032 cadmium plated sheet steel	2	31	450	32

Eleven distinctly different metals in nineteen gages were spot welded to the same material as were twelve combinations of dissimilar metals as a direct result of the extremely short accurate timing made available by the "Ignitron" Control.

Carbon Arc Welding in Marine Construction

By FRANK HIRNER†

OLD methods of U. S. cutter construction went into discard recently when the Gibbs Gas Engine Company of Florida, owners of the largest dry dock in the state, were awarded a contract to build five 80-foot patrol boats for the United States Coast Guard.

All-Welded Monel Metal and Silicon Bronze Specified

The government specifications required that the fuel oil tanks as well as all other metal tanks be welded, although the type of welding was not specified. The 2000-gallon capacity fuel tanks were to be constructed of 14-gage silicon bronze, divided into two compartments of 1000 gallons each, with necessary swash plates. The water tanks were to be constructed of 16-gage monel metal. In addition to the tanks, specifications called for full length X-strapping on each side of the pilot house between frames and planking to retain fore and aft rigidity—these also to be welded.

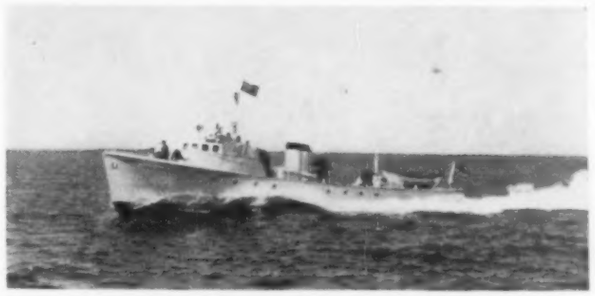
Experiments with Electric Arc

Past experience with welding copper and bronze by the electric-arc had convinced Mr. Bouchelle that electric arc welding might well be applied to his particular problem. He began to experiment with the welding of silicon bronze and monel metal to find the electrode that would suit their needs. It was soon discovered that the average electrode would allow the parent metal to flow too quickly under the electrode arc to be practicable.

Experiments were then begun with a $^5/_{32}$-inch carbon electrode carrying about 125 amps. This amount of heat was too great, and the amperage was gradually worked down to around 65 amps. with a $^5/_{32}$-inch carbon electrode and $^1/_8$-inch filler rod of silicon bronze, where proper temperature was maintained.

The flux used was composed of borax and silicate of soda. In practice, the positive polarity cable from the welder was grounded to the work, the negative cable connected to the carbon electrode and the $^1/_8$-inch filler rod fed into the arc with the left hand. It is easy to understand that the success of the welding depended even more upon the skill of the operator than in any other type of welded construction.

Pilot House Completed. Seams, Ports and Port Frames Integrally Welded



The Finished Patrol Boat Doing About 25 Knots on Test Run

However, once a method was decided upon the welding job went ahead rapidly to completion. All government tests were passed with ease even when the tanks were filled with distillate and tested with three-foot head pressure.

A Real Economy

Estimates have shown that the footage speed compared with that on a steel welding job was about a 3 to 1 ratio. More important is the fact that the cost of welding with this carbon arc system showed itself to be only about a fourth of that which had been estimated.

† Welder Division, Harnischfeger Corporation.

Approved Method for Repairing Furnace Crowns

By H. C. SHEPHEARD†

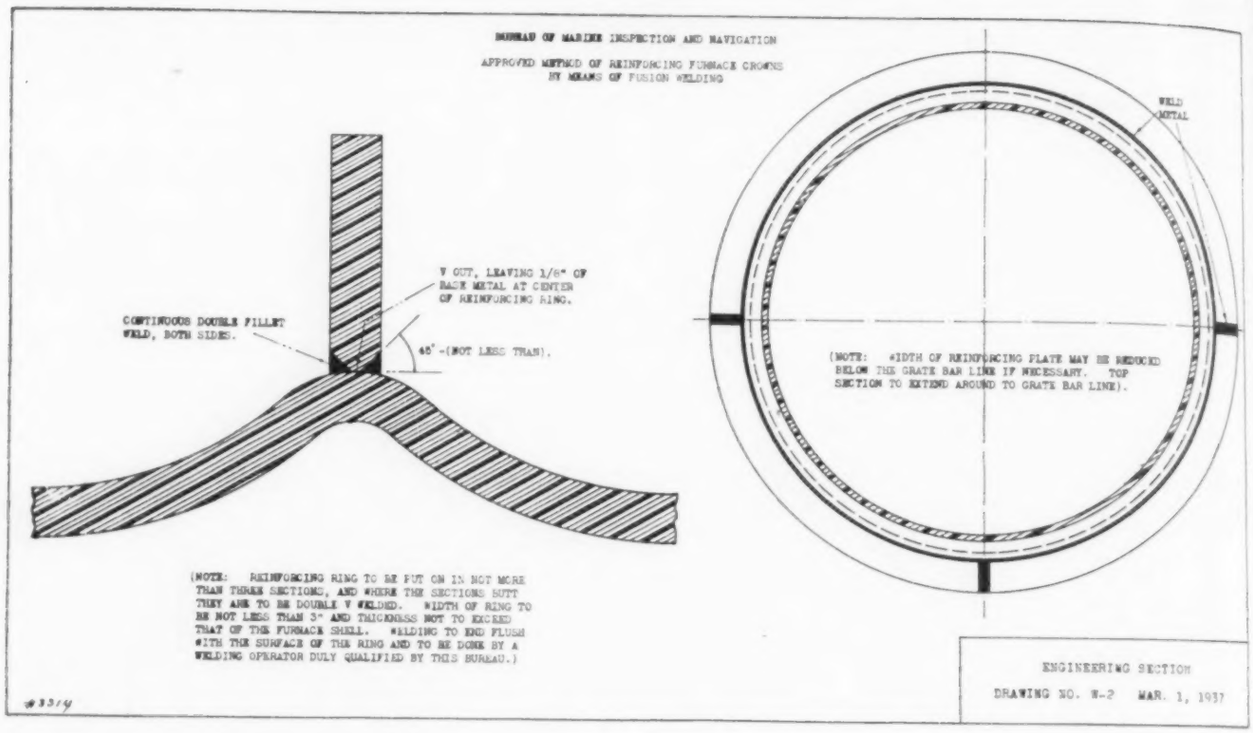
FIGURE 1 is a sketch designated as drawing No. W-2, showing a method for reinforcing furnace crowns which have become distorted. The procedure for applying this method of repair is as follows:

The furnace crown where distorted should be pumped back as nearly to a circular form as it is possible to attain. It should be measured and a template made conforming to the shape of the furnace crown. From the template, plates should be formed to make a complete ring to envelop the furnace. This ring should be in two if possible, but not more than three sections. The upper section should encircle the top half of the furnace. The edges shall be attached to the furnace crown and be beveled to an angle of not less than 45 degrees on each side of the ring to permit attachment by a double fusion weld, the weld to be continuous around the periphery of the furnace, and the sections joined by butt welding, as shown in the sketch.

This repair must be done by welding operators who have passed the qualification tests of the Bureau, and the use of an approved shielded electrode is required.

If necessary, the sections of the reinforcing ring below the center line may be reduced to permit clearance where stays are installed or where the shell is too close to the crown of the furnace to permit the full section to be used.

† Assistant Director, Bureau of Marine Inspection and Navigation, Washington.


BUREAU OF MARINE INSPECTION AND NAVIGATION
APPROVED METHOD OF REINFORCING FURNACE CROWNS BY MEANS OF FUSION WELDING
WELD METAL
V CUT, LEAVING 1/8" OF BASE METAL AT CENTER OF REINFORCING RING.
CONTINUOUS DOUBLE FILLET WELD, BOTH SIDES.
45°-(NOT LESS THAN).
(NOTE: WIDTH OF REINFORCING PLATE MAY BE REDUCED BELOW THE GRATE BAR LINE IF NECESSARY. TOP SECTION TO EXTEND AROUND TO GRATE BAR LINE).
(NOTE: REINFORCING RING TO BE PUT ON IN NOT MORE THAN THREE SECTIONS, AND WHERE THE SECTIONS BUTT THEY ARE TO BE DOUBLE V WELDED. WIDTH OF RING TO BE NOT LESS THAN 3" AND THICKNESS NOT TO EXCEED THAT OF THE FURNACE SHELL. WELDING TO END FLUSH WITH THE SURFACE OF THE RING AND TO BE DONE BY A WELDING OPERATOR DULY QUALIFIED BY THIS BUREAU.)
#33/4
ENGINEERING SECTION
DRAWING NO. W-2 MAR. 1, 1937

Welding in the Construction of Building Piping Services*

By A. S. McCAWLEY†

OUR firm is in the heating, piping and air conditioning business. The field encompasses steam and hot water heating piping, power piping, gas and air piping, water piping, piping for oil and a multitude of various kinds of systems for process work. A new and extensive field is air conditioning.

Some years ago I had occasion to make a survey of the future market for welding in this connection. I believe the results of the survey will interest you.

In making up the survey we obtained, from the Marketing Staff of Engineering Publications, the mean annual consumption of pipe by the heating and piping industry for the years 1927–28–29 which amounted to 1,350,000 tons per year. Then several welded installations we had made were carefully checked for the number of inches of weld made per ton of pipe installed. We found that there were 83 lineal feet of weld per ton of installed pipe. For conservatively figuring average conditions a deduction of 35 per cent was made from this figure leaving 54 lineal feet of welding per ton of pipe to be considered.

Then a deduction of 25 per cent from the total pipe consumption of the industry was made to account for pipe used for replacement purposes in screwed fitting installations; for pipe below one inch in size that ordinarily would not be welded and other pipe that would not be welded under any circumstances, leaving a conservative total tonnage of pipe to be welded of 1,012,500 tons.

Putting these two sets of figures together—the 54 feet of welding per ton of pipe and the total pipe consumption of 1,012,500 tons we have the impressive total of 54,675,000 ft. of welding. Based on a cost of 11¢ per inch for preparing and welding the joints that tonnage amounts to $72,171,000 which you will agree amounts to important business.

We assumed in making the foregoing survey, due to the many advantages of a welded pipe system, that by 1940 at least 75 per cent of the pipe used by our industry would be welded and that screwed installations would be obsolete. The depression set that estimate back a bit but we feel now, with the building industry on the road to normalcy that this prediction will be true in less than ten years. There is still a lot of promotional work to be done to obtain this $72,000,000 worth of business annu-

*Presented at April 16th Meeting, Chicago Section, AMERICAN WELDING SOCIETY.

†Thos. J. Douglass & Co., Heating—Air-Conditioning Contractors.

ally for the welding industry—promotional work among the owners, architects, designing engineers and the specification writers, some of whom remain to be convinced that for a permanent, tight, easily insulated pipe system of pleasing appearance, welding must be used.

In our business which is 99 per cent contract work of a highly competitive nature, we've worked out procedures for installing pipe systems in what we think is the most economical way. For years with screwed joint pipe systems we have laid out all runs of pipe over 2 inches in diameter in a sketch showing pipe sizes, locations of tees, elbows, valves, etc. The whole sketch is accurately dimensioned and then sent to the pipe and fitting supply house, the manufacturer's jobber, who supplies the material and cuts and threads the pipe. This is done on specialized machinery with low cost labor. The material is then sent to the job where steamfitters install the hangers and screw the pipe in place.

Our first experience with welded piping, however, was a different story. It was the Carbide and Carbon building which was the first welded heating system in Chicago. We had no precedent to follow in job procedure and no capable union steamfitter welders.

Random length pipe was sent to the job and installed by the "cut and try" method which turned out to be very costly. The result of this experience was the development of a machine by our organization for use at the material source to cut and fit all pipe from sketches in the same way we had always handled screwed installations. These machines which we manufactured and sold to several supply houses in the Chicago area cut and bevel the pipe in one operation by means of an oxyacetylene blowpipe. The machine will make miter piece elbows and tees of all sizes and tees with reduced branch sizes. The cut surfaces are extremely smooth and the fit so perfect that the oxyacetylene welding which is done on the job is considerably speeded up. Too, since the Carbide and Carbon job was installed, the Steamfitters Union in conjunction with the Chicago Master Steamfitters Association has established a welding school for members of the union, greatly simplifying the labor problem.

We made frequent and profitable use of our gas cutting and welding equipment in ways other than straight joint welding—in dismantling old boilers, pipe runs, pumps and engines—in the fabrication of special pipe hangers and clamps, for hard surfacing stoker and ash handling equipment parts that are subject to abrasive action.

Last week during a test on a 6-inch well water line in the new air conditioning system at the Fair Store in Oak Park a leak showed up in a defective malleable fitting. The fitting was a considerable distance from a union connection. The normal procedure would be to cut the pipe adjacent to the fitting, send the cut piece back to the supply house for threading, and making on of a union and elbow. The assembly would then be returned to the job for reinstallation and the cost would be about $75.00 as the fitting was in a difficult place to work. We repaired the 2-inch crack in the fitting with the welding blowpipe and manganese bronze rod at a trifling cost. Even where screwed fittings are specified, as in this case, welding is a mighty handy tool.

There are systems for a number of special uses where the pipe *must* be welded—no other low cost type of joint will fill the bill. On ordinary heating systems, from the standpoint of *operation* of the system, screwed fittings are

Gas Piping to Power Boilers in the Blackstone Hotel, Chicago

Gas Piping to Power Boilers in the Blackstone Hotel, Chicago

satisfactory. Steam pressures from a few ounces to ten pounds are ordinarily maintained. Should there be bad joints in such a system expansion of the metal and corrosion combine to prevent steam from escaping. However, with some of the newer heating systems where a high vacuum is carried on both the steam and return, the problem is to keep the air out of the system as there is no heat in the in-rushing air to expand the metal surrounding the leak. Such systems—to conserve fuel—are designed to automatically vary the pressure on the steam side of the system from a very high vacuum to several pounds pressure thus varying the temperature of the steam and consequently the heat output of each radiator. Welded joints solved the problem of air leaks in these systems.

Another instance where welded joints are absolutely essential for a tight system is on hot oil piping. We have installed several large combination gas and oil fired power boilers here in Chicago to take advantage of the extremely low gas rates allowed by the Public Service Company during portions of the year when the domestic heating load is low. During the winter heavy viscous Bunker "C" oil is burned. At room temperatures this oil will hardly flow through the pipe but when heated to 240 degrees for burning nothing but a welded joint will hold it.

In closing I would like to emphasize that we consider welding one of the most important tools that we have—one that would be very difficult to do without, now that we've learned to use it.

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Index to Advertisers

THE WELDING JOURNAL

Air Reduction Sales Company . Outside back cover
American Brass Company 43
American Telephone & Telegraph Co. 40
Anti-Borax Compound Company 46
Bastian-Blessing Company. 46
Chicago Hardware Foundry Company 46
General Electric Company . . . Inside front cover
Harnischfeger Corporation 39
Lincoln Electric Company. . . . Inside back cover
P. R. Mallory & Co., Inc. 46
Metal & Thermit Corporation 42
National Carbide Corporation 47
John A. Roebling's Sons Company 42
Victor Equipment Company 41
Weldit Acetylene Company 47

WELDING SOCIETY ACTIVITIES
AND RELATED EVENTS

A Message from Our President

To the Members of the
AMERICAN WELDING SOCIETY:

A telegram has just been laid on my desk; it reads: "President's Message July Journal not received stop closing forms Friday," signed "W. Spraragen." That means a month has skidded by since the last similar message. It seems like only four or five days ago.

During this past month we have had the nomination of officers for next year. The Nonimating Committee made a wise choice in Mr. Lang. He is a worker, has a fine grasp of the fundamentals of welding, and will make history for the Society next year. There will be at least three more Executive Committee Meetings before the change of officers in October, and I shall ask Mr. Lang to sit in on all of them. I well remember the mental confusion I encountered jumping into the job of chief executive out of a clear sky, and I know it will help Mr. Lang a lot to get into the swing of things before he has to start writing fifteen or twenty letters a day, many of them on subjects which will be new and unfamiliar. I hope Mr. Lang, who is a railroad man, has an annual pass for Pullmans as well as a railroad pass. It will come in handy. I also hope he will be able to pick up and travel at will, because the demands which will be made on his time will be large.

There is one satisfying aspect to being president next year. It's the splendid job which your Management Committee and your Membership Committee has done this year. Not that a lot of others haven't done fine work too, but these two Committees have had certain definite objectives and they have handled them in a splendid manner.

Mr. Lang will find the program of the Ways and Means Committee well organized and working. He will find much wider industrial support of the Society's activities than a year ago. The progress we have made this year, considering the hurdles we have had to clear, is creditable, but I feel that it is only a start. With the impetus gained so far, our progress next year will be truly outstanding. Knowing how deeply appreciative I am of the splendid support received the last eight months from the rank and file of our membership, I shall volunteer to be of whatever service I can to our incoming president.

I can't seem to catch up with that man, Hays. My wires come back marked "left for parts unknown." I wish I could give you a detailed report of member interest throughout the middle west and south where Mr. Hays has been flitting about stirring up interest. I do know that it looks as though before long we will have a whole string of new chapters from Minneapolis straight through to New Orleans. There will be several new ones in Texas. Birmingham is practically assured. Altogether twenty-four chapters (there were twelve last fall) by the time of the annual meeting should be easy.

Speaking of chapters and members, here is one for the record: Mr. H. C. Boardman, middle western Vice-President, just wrote in that they sold eighteen (count them) eighteen new memberships to the Whiting Corporation, Harvey, Illinois. There's a forward looking corporation for you, and I'll wager they never spent a couple of hundred dollars that paid better dividends than this investment will. Just one little idea, such as I have gotten many times through my association with the Society, will make the investment profitable.

Whitey Murauth has come back from Honolulu with a fine story of the new chapter there. In a couple of months my old friend, Eddie Neville, is leaving to take up the office of Minister to Siam. I am to have dinner with Eddie tonight and I'll see what he can do about organizing a chapter in Hancock. If it takes, I speak for the job of going over to install the chapter. Siam has always had an appeal to me with its twins and white elephants and those funny little dancing girls.

Sorry, really you deserve something better than this letter. I'll speak to the editor; he'll have to give me more time in the future. All I could do on this one is to just talk naturally instead of writing a proper kind of letter such as a president should.

Sincerely,
A. E. GIBSON,
President

PHILIP G. LANG, JR.

It is with pleasure that we reproduce below the first two pages from the June 1937 issue of the Baltimore Engineer.

June recently took its place in the calendar, exposing on the new leaf, "Annual Meeting of Engineers' Club" with all it implies in sad farewells for the old, tried and true, and welcome for the new, untried but true who have accepted the responsibility to guard and guide us for the year to come.

Paul Holland retires from the Presidency, and after a report of his stewardship, contained on another page, assures us of his continuing interest.

Philip G. Lang, Jr. succeeds to the Presidency.

Mr. Lang's membership extends back for many years and, always, profitable ones for the Club.

He is Engineer of Bridges for the Baltimore and Ohio Railroad Company, past-president of the local chapter of A.S.C.E., is prominent in the AMERICAN WELDING SOCIETY and always active in any movement for the improvement of the professional or social condition of the engineer.

His ripened engineering judgment combined with his knowledge of Engineers' Club, the affiliated societies and their inter-relationships, well fits him for the responsibilities he assumes.

Only love of engineers and engineering could prompt him to such sacrifice of his Professional time as the Presidency requires.

Such qualifications as his, invite our service. To those whom he offers Committee memberships, shall they not accept in the very best spirit, hoping thereby to join with him in lasting service to Engineers' Club?

The other officers and directors newly elected have our approval. To Mr. Lang and them, for the honor they receive, and to our membership, for their acceptance of the honor, we offer congratulations and best wishes for a year of activity and progress.

Foreword

Fellow Members: I am deeply sensible of the honor and confidence you conferred upon me by selecting me at the late elec-

tion as the President of your Club for the coming year, and assure you of my best endeavors to fulfill the trust.

To me the immediate future of the Engineers' Club is a problem that requires careful consideration at the present time.

The "Depression" is certainly believed to be behind us by six months or more. Our Club, under the able administration of the retiring president and previous presidents with their officers, boards and the exceptional cooperation of the membership in general, has come through the period of gloom in an unruffled condition.

Much has been done since 1932 to alleviate the unfortunate status of many engineers. The Club has served constantly as a sanctuary, not only for its own members, but for all technical men of Maryland. The Engineers' Relief Committee, an important adjunct of the Club, aided hundreds of engineers (mostly non-members) who needed assistance, and for its own members the Club materially reduced its annual dues. However, now that we are again in still water, the question arises: Are we, with feelings of gratitude for our escape and the resumption of normal conditions, to sit down placidly and without progress wonder "*What's Next?*"

I say, *No!!* Because standing still means retrogression, and furthermore, it seems to me that the time has now arrived when, having served the engineering profession in general, through the bad period, the Engineers' Club should move to permanently improve its own Club conditions.

Very shortly the standing committees will be appointed, and preparations will be made for the coming year's work, and I ask that during the dull season of the hot weather, before the activities again begin, every officer, director and member of the Club give consideration to what we should do along the lines of "Permanent Progress."

Many of us have thoughts on this subject. Let's put them on paper, gather them in, review them and when we assemble for fall work, we must be determined upon a pronounced policy of achievement that includes, but goes much further than an interesting and successful Wednesday noon luncheon table talk program.

Some of the matters worthy of earnest consideration are: Increased revenue other than from increased membership; Increased membership; The dining room problem; Centering affiliated engineering societies' activities in the Club; Series of monthly evening Club meetings during the winter months, presenting prominent speakers on appropriate subjects; and last, but not least, now that the Club is nearly one-third of a century old, serious consideration should be given to the possibility of securing, within our means, modestly at the start, Club-owned quarters. Numerous other lines of improvement and progress can be envisaged.

We cannot stand still; we must go forward; working not alone for ourselves—simply holding what is handed down to us—but marching onward for the good of all Baltimore engineers. With everybody working together, we cannot fail.

I conclude by slightly paraphrasing Edmund Vance Cook's "How Do You Battle?"

Do you tackle the work that comes your way
With a resolute heart and cheerful
Or hide your face from the light of day
With craven soul and fearful
The harder you're thrown the higher you bounce
Be proud of that blackened eye
It is not the fact that you're licked that counts
It's how did you fight and why?

P. G. LANG, JR.

New Sections in the Making

By WARNER S. HAYS

The past three months were planting time in the corn belt and the AMERICAN WELDING SOCIETY planted seeds for development into full grown sections in the early fall, in many centers of the Central West, South West and South East.

We found and visited some of the largest welding using plants in these points and learned what members and potential members wanted in service from the Society. Visiting hundreds of plants in many states makes one realize there is need for an AMERICAN WELDING SOCIETY.

Welding engineers and executives have thought of joining, but New York seemed far away—and not since a visit several years ago by some past officer has any representative of the Society called. Mr. Gibson has done a herculean task visiting and establishing several new Sections. Mr. Davis and his fine membership committees have aroused interest and invited many to join. They have the whole country talking AMERICAN WELDING SOCIETY and the advancement of welding. But it takes some local enthusiasm and leadership to achieve results.

This has now been supplied and fine cooperation and work is being done by committees in every city visited. By the Annual Meeting in Atlantic City in October, to which many new members are coming, we should see most of these Sections functioning and represented the same as those fine Sections long organized. We hope to see the Portland Section revitalized.

Omaha, Neb., has an able organization committee under Heinie Schneiderwind of the Will-Weld Mfg. Co. and Omaha Welding Co., O. E. Engler of the Balbach Co., B. L. Fuchs of the Fuchs Machinery and Supply Co., G. E. McGrath and Einer Claussen of the Eaton Metal Products Co., who promised to have at least 50 members from that area in the Society, and the section definitely established before summer. An enthusiastic preliminary meeting was held in Omaha on Monday evening, the 24th of May.

Central Iowa, with Des Moines as a focal point, under able leadership of Mayor Bill Allen of Ames, Mr. Boian, Chief Engineer of Pittsburgh-Des Moines Steel Co., and Mr. Miller of Major Welders, following an educational meeting or two in the early fall should become an established section.

Minneapolis or the North West Section, under the leadership of Harry Kicherer of the American Hoist and Derrick Co. of St. Paul, held its preliminary meeting on Friday, May 21st, arranged by R. H. Newton and by the middle of June will have completed the first membership campaign to secure definite authorization as a regular established section. This section should achieve 75 or more members by the beginning of the regular fall program in September. V. L. Sage of Commercial Gas Co. and the Smith Welding Equipment Co. and Marquette Mfg. Co. are cooperating in every way to help build this important North West Section of the society, as are all other representatives in Minneapolis and St. Paul.

The Quad Cities, Davenport, Rock Island, Moline, East Moline and Bettendorf (really Quintuplets) promises to be a section in the early fall, following a preliminary educational meeting.

Peoria has displayed unusual activity in welding, and may also join the list of welding Society sections in the early fall.

On June 4th, with President Gibson we assisted in the organization of the St. Louis Section. What a live crowd they had and this Section will grow rapidly under leadership of Chairman A. W. Harris, F. A. Fantz, Lockwood Hill and others.

On June 1st we had the pleasure of enjoying a dinner meeting with the Executive Committee of the Chicago Section and had a similar one with the men of the Philadelphia Section on June 28th. We are checking possibilities of a Section in Northeastern Pennsylvania, in Connecticut and in the Rochester, New York areas. In this last and Buffalo area much hard work is being done by member Martin P. Korn, Engineer.

In Tulsa, Okla., our good member Jay Walker of National Tank Company was host to 26 at a fine luncheon on June 5th. A live organization committee is at work under the leadership of Richard R. Thompson of Air Reduction Sales Co. and this new Section will soon be duly established.

Oklahoma City, not to be outdone, under the guidance of members Gwynne Raymond (a former Vice-President of the Society) and Kenneth R. Banks, also threw a luncheon on June 7th for 28 and elected a live committee consisting of Otto Hart, Chairman; Hart Welding Supply Co., and Kenneth R. Banks, Secretary. They signed up eleven new members right at the luncheon—and with eight already in—they should have no trouble completing their basic roster of 25 by July 1st and pledge 50 before fall. The Society's Southern Vice-President E. E. Dillman of Wyatt Metal & Tank Company, was host at a dinner June 8th to some thirty representatives of welding users in Dallas and Fort Worth. A committee was named to canvas the area to see if additional members could be secured to form a Section. They plan another meeting and speaker in mid July when they hope to complete formation of North Texas Section.

Houston will be the center of South Texas Section. Twenty-four new members including several sustaining were pledged at a meeting arranged June 10th by B. H. Smith of the Big Three Welding Equipment Co. He gave a fine opening address,

Walter Van Wert another member from the Houston Plant of Wyatt Metal & Tank Co. was named Chairman of Committee to complete details of forming this Section. Until one visits the plants in this area and sees the volume of welding and working conditions, he can't realize how active welding is and how much they are doing—welding oil well casings in the hole, etc.—many striking uses of welding.

New Orleans is a possibility for later development. On June 12th, A. H. Guillot of New Orleans Public Service, Inc., our Sustaining Member, helped us make valuable contacts with potential members and to lay plans for activity and growth in this area.

Southern Vice-President nominee W. J. Sannemann and member E. E. Michaels of Chicago Bridge & Iron Works and J. E. Durstine of Lincoln Electric, W. F. Roberts of Air Reduction Sales Co. and W. A. Post of The Linde Air Products Co. and Jas. J. MacKenzie of American Cast Iron Pipe Co. have done a real job at Birmingham.

A luncheon for twenty and evening meeting of some 70 on June 14th brought pledges of support sufficient to assure a live Section around Birmingham.

Likewise in Atlanta members W. C. Snead of Link Belt Co. and L. A. Wallace, Atlantic Steel Co., R. G. Wilson of Compressed Ind. Gases and R. J. Teedle of Page Steel & Wire Co., rallied out a fine turnout of some 35 on June 15th and signed up enough that night to assure the Atlanta Section. Forming a Section in Atlanta will achieve a dream of the late George Bird long a member of the Society, whose son, George T. is carrying on and rendering help to the committee. Guy Howard Williams, traveling welding instructor for General Fire Extinguisher Co. made a short address and plea for careful instruction of welders giving experience of his work. Professor Harrelson described at length the welding courses and results at Georgia Tech and made strong plea for Atlanta Section and offered complete cooperation.

Chairman Snead and Secretary Wilson are busy completing the necessary details to secure charter, etc. for this new Section. They, too, plan a meeting early in July.

Then to complete the South group and make 7 new chapters from these fourteen states on June 16th a group of 26 leading users of welding in Chattanooga had a luncheon meeting. Members Chester T. Raymo, Ed. C. Chapman and Robert Daniels and others had worked well. Mr. A. J. Moses of Hedges, Walsh, Weidner Co. gave a fine address as did William E. McKenzie, a visitor from U. S. Navy department and member of the Baltimore Section. Support was pledged and signed up enough to guarantee a fine Section forming out of Chattanooga.

San Joaquin Valley Section Under Way

On the evening of June 2, 1937, a meeting was held in Taft, Calif., for the purpose of forming a Section of the Society in the southern part of the San Joaquin Valley. This meeting was presided over by Regional Vice-President Mr. Turner Smith of Los Angeles, Calif., and by Mr. Wayne Howard, Chairman of the Los Angeles Section, Los Angeles, Calif. The meeting was attended by a representative group of men interested in welding.

Mr. Turner Smith opened the meeting with a very interesting presentation of the history, function and operation of the Society. Following this presentation he called for the nomination and election of temporary officers.

The following officers were elected and will serve until the first regular meeting which will be held in September:

Chairman—Mr. P. Rintoul, Taft, Calif., Manager Western Water Co.

Vice-Chairman—Mr. E. E. Mosher, Taft, Calif., Engineer, General Petroleum Co.

Secy.-Treas.—Mr. H. S. Nix, Taft, Calif., Instructor, Taft Junior College.

Mr. Wayne Howard, Chairman Los Angeles Section, gave a very interesting résumé of the functions and operation of the various committees necessary for the best interests of the Society.

Some thirty members registered. Mr. C. J. Nyquist of the Weldcraft Co., Los Angeles, presented a most interesting review of the history of welding, after which the meeting was adjourned.

Business to Be Combined with Pleasure at Summer Session of A. I. E. E.

According to Mr. K. L. Hansen of the Harnischfeger Corporation, Milwaukee, Wis., who is general chairman of the summer convention committee for the American Institute of Electrical Engineers, there will be opportunities for both work and play when Institute members gather in Milwaukee on June 21st for their annual summer meeting. Well aware of the effects produced by too much work and no play, Mr. Hansen has developed such a well rounded program that keen member interest is insured throughout the four-day period.

Beginning with registration at 9 o'clock Monday morning, June 21st, and ending with a farewell gathering on Friday evening, June 25th, the convention is to include in its business session a wealth of pertinent and up-to-date technical discussions, combined with inspection trips through the Harnischfeger Corporation, Cutler Hammer, Inc., Allis-Chalmers Mfg. Co., Port Washington Power Plant, A. O. Smith Corporation, Globe Union Mfg. Company and Allen-Bradley Company.

Ten technical sessions have been tentatively scheduled to provide a program of broad scope in current interest. Two sessions will be held on the subject of lightning protective equipment and insulation coordination.

The subjects for other sessions are as follows: Power transmission, general power application, education, power generating and electrical machinery, illumination, vibration and balance, communication and research, and instruments and measurements.

Tuesday evening, June 22nd, the meeting is open to the public to give them an opportunity to hear a lecture by Dr. Vannevar Bush in which he will talk on "The Engineer and His Relation to the Government."

Wednesday morning, the session will deviate from the usual, when the spotlite will be centered on a meeting of such importance that no other meetings will be held concurrently. The principal speaker here will be Dr. Ralph E. Flanders, past-president of the A. S. M. E. He will speak on "The Engineer in a Changing World."

To gain relief from sustained mental activity, Mr. Hansen has arranged for a stag smoker Monday night, an inspection trip through Schlitz Brewery which is to include refreshments on Tuesday; a Lake Michigan boat trip on Wednesday; a dinner dance on Thursday, and the convention is officially closed with a dinner at the Bluemound Country Club on Friday night. Golf and tennis tournaments will be held as usual.

A post-convention trip to the beautiful Dells of Wisconsin has also been scheduled for the many people who will not wish to miss the opportunity of seeing this attractive and historical area.

Summed up, with the mornings devoted to technical discussions, the afternoons to inspection trips, sports and committee meetings, and the evenings entirely given over to social functions and entertainment, it will undoubtedly be a meeting of unflagging interest to Institute Members and their families.

Iron and Steel Engineers Meeting

Five hundred members and guests of the Association of Iron and Steel Engineers are expected to attend the inspection trip being conducted by this society to the new 100 inch semi-continuous plate mill of the Carnegie-Illinois Steel Corporation, Homestead, Pennsylvania, on the afternoon of June 23rd. In the evening of the 23rd there will be a meeting of the Association at the William Penn Hotel, Pittsburgh, Pennsylvania, where a symposium on Flood Control and Rehabilitation will be presented. This meeting will be preceded by an informal dinner at 6:30 P. M.

Oklahoma City Section in the Making

What is no doubt the first step toward the establishment of an Oklahoma City Section of the AMERICAN WELDING SOCIETY, was taken Monday, June 7th at a gathering of those interested in welding who met at a luncheon in the Biltmore Hotel.

Mr. G. Raymond, as acting chairman of the meeting, told briefly of the purpose of the meeting and then introduced Warner S. Hays, Managing Director of the AMERICAN WELDING SOCIETY who outlined what the Society as a national organization contemplates doing in the

near future in the way of research work, the establishment of what might be termed a lecture board whose members will be available for addresses throughout the territory. Mr. Hays also called attention to the publication in the near future of a Welding Handbook which is to be printed by the Society. Mr. Hays then explained the benefits to be derived from the establishment of a Section of the AMERICAN WELDING SOCIETY in Oklahoma City and the necessary preliminary steps for organization.

Eleven of those present signified their intention of becoming members of the Society. These, together with the five members, form a nucleus of sixteen, which led to a decision to form a Section on Oklahoma City. Mr. Otto Hart was elected temporary chairman and Mr. K. B. Banks temporary secretary. Everyone felt that the required number of members could be secured.

Resistance Welding Data

Resistance Welding has made tremendous advances during the last few years. It has made possible the fabrication of many similar and dissimilar metals, forgings and stampings into finished products of strength, lightness and symmetry at a speed unequalled by any other known process.

The P. R. Mallory & Co., Inc., of Indianapolis, Ind., have just issued an attractive book of 96 pages, copiously illustrated, containing very valuable data.

The purpose of this book is two-fold: (1) to give plant executives, engineers and shop men a clear, comprehensive picture of the entire resistance welding field, and (2) practical data of methods, materials that may be welded, and proper electrodes and dies.

Lincoln Arc Welding Prizes

Cleveland, Ohio, June 1, 1937—Dr. E. E. Dreese, Chair of the Board of Trustees and of the Jury of Awards, The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, today issued a statement further clarifying the object of the Foundation's $200,000 Series of Awards. Such clarification is necessary, reports Dr. Dreese, in view of a feeling which apparently exists that only individuals familiar with the use of electric welding have an opportunity to participate.

"The idea that the opportunities of the Lincoln Foundation's $200,000 awards are available only to individuals familiar with electric welding and its use, is entirely erroneous," states Dr. Dreese. "Although a definite object of the awards is to urge architects, engineers, designers and production managers to study products which are now partially welded so that electric welding may be applied more extensively, the primary object is to encourage study of products and structures built by some other method so that electric welding may be used in construction.

"Ample time is allowed by the duration of the Foundation award program—closing June 1, 1938—to permit engineers to acquire sufficient knowledge of the principles of arc welded construction to apply the method in product or structure redesign. To be suitable as subject matter for a paper, it is not necessary that the product or structure be built entirely by arc welding. The rules of the Foundation state that 'the machine, structure, building, manufactured or fabricated product may be designed, either in whole or in part for the use of arc welding.'

"There is a tendency to regard arc welding as something mysterious and complicated. Nothing could be further from the truth. To be able to design for arc-welded construction requires only the addition of welding knowledge to fundamental design knowledge. The designer readily learns the basic principles of arc welded design because of the inherent simplicity of welding, acknowledged as the simplest process for joining metals. Application of this process is one in which practical skill and ingenuity.

Minneapolis Chapter Being Formed

A preliminary organization meeting of the Northwest Chapter of the AMERICAN WELDING SOCIETY was held at the Minnesota Union, University of Minnesota, Minn., on June 21, 1937. Some of the leading executives of Minneapolis and St. Paul were present. Mr. Harry J. Kicherer, Works Manager of the American Hoist & Derrick Company, acted as Temporary Chairman. After dinner was served the Chairman stated that the meeting was called to consider the organization of a chapter of the AMERICAN WELDING SOCIETY. He explained the purposes and activities of the Society and different kinds of membership and the benefits that would accrue from membership. He called upon those present to express their views as to the desirability of organizing such a chapter. All of these were distinctly favorable. 35 joined or indicated their intention of joining. The following Nominating Committee were appointed for the nomination of officers and members of the Executive Committee.

G. V. Watson, Chairman, Flour City Welding Co.
J. H. Barron, Brown Sheet Iron & Steel Co.
C. E. Comfort, St. Paul Structural Steel Co.

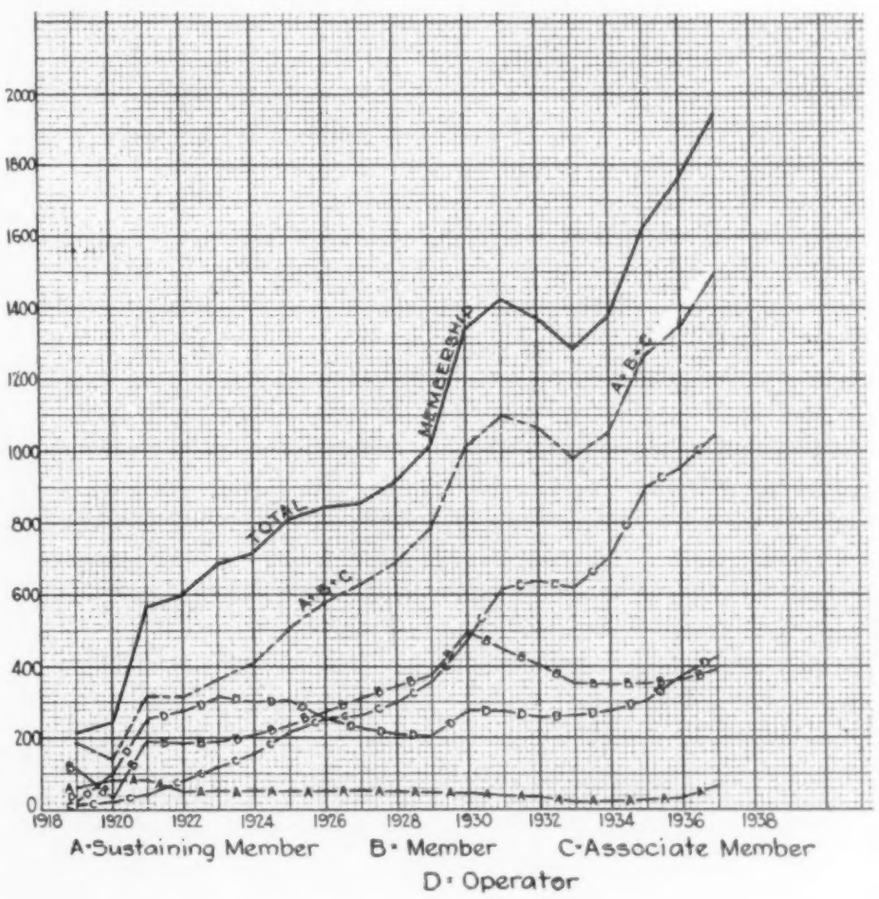
A By-laws Committee was appointed to prepare by-laws for the proposed Section.

Mr. Howard Chatfield, Supervising Engineer of the Fidelity & Casualty Company of New York, presented an interesting paper upon the subject of "The Importance of Skill in Welding." At the conclusion there was considerable discussion upon the points raised in the paper.

Another meeting of those interested will be held shortly.

Membership Growth

The chart shown below was prepared by Mr. G. H. Dayett, Designing Engineer, The Baltimore and Ohio Railroad Company, at the suggestion of Mr. P. G. Lang, Jr., Engineer of Bridges of the same organization.



Steel Sheets

Published with the title "USS Electrical Steel Sheets," a new booklet embodying the latest factual information on this specialty product has been released by the Carnegie-Illinois Steel Corporation, subsidiary of United States Steel Corporation.

Introductory pages tell the history of the development of electrical steel sheets. A clear exposition of terms commonly used by electrical engineers and designers, including normal magnetism, normal and intrinsic induction and hysteresis loss, serves as a ready reference section.

Features of the new booklet are the descriptions of modern mill technique in producing electrical steel sheets, and of the rigid tests for electrical and mechanical properties to which sheets are subjected. Ten grades of USS Electrical Steel Sheets are discussed in reference to their many applications.

Useful data include conversion tables, the new table of Guaranteed Maximum Core Losses, and information on magnet wire and varnished cambric insulated cables.

A number of striking photographs and photomicrographs illustrate operations with and applications of electrical steel sheets.

Copies are available to interested readers.

Address: United States Steel Corporation Subsidiaries, P. O. Box 176, Pittsburgh, Pa.

New A. S. T. M. President

Nominations for officers of the American Society for Testing Materials, for 1937–1938 are announced. Official notice of election will be given at the first session on June 28th, of the Fortieth A. S. T. M. Annual Meeting in New York City.

President: (Term—one year)

A. E. White, Professor of Metallurgical Engineering, and Director, Department Engineering Research, University of Michigan, Ann Arbor, Mich.

Following his graduation from Brown University, 1907, and a year of study at Harvard, 1908, Doctor White was in charge of research on blast-furnace by-products, ores, etc., for Jones & Laughlin Steel Co. In 1911 he became instructor at the University of Michigan, assistant professor 1913–1917. He has held his present positions since 1919. From 1917 to 1919 he served in the Ordnance Department, U. S. A.—was head of the Metallurgical Branch, Inspection Division and also head of the Metallurgical Branch Technical Staff. He is now Lieutenant-Colonel, Ordnance Reserve Corps. Doctor White is active in the work of several A. S. T. M. committees in the metals fields and chairman of the steel committee's group on materials for high-temperature service. He was the first president of the American Society for Metals and is a past-chairman of the research committee, American Society of Mechanical Engineers. In 1925 Brown University awarded him the honorary degree of Doctor of Science. From 1933 to 1935 he was a member of the A. S. T. M. Executive Committee and is completing a term as Vice-President, 1935–1937. Dr. White has been active in the research work of the AMERICAN WELDING SOCIETY.

Birmingham on the Way

The first meeting of a group of interested people in Birmingham, Alabama was held on Monday, June 14th. A luncheon meeting of the present members and others especially interested was held on that day. In the evening the main meeting was held at which sixty-one attended. A round table discussion was started and the subject of welding cast iron was brought up. Mr. Johnston of the General Welding Company, Dr. MacKenzie of the American Cast Iron Pipe Company, gave very interesting reports from their experience and experiments along this line.

Mr. Belden of The Linde Air Products Company discussed super-hard surfacing of cast iron. Enough A, B and C members were signed up at the meeting to form a Section and it is hoped that one will be started in the immediate future.

Mr. Warner S. Hays, Managing Director of the Society, outlined the objects of the AMERICAN WELDING SOCIETY and gave some very constructive points on getting members.

Temporary officers were elected as follows:

Chairman—E. E. Michaels, Manager, Chicago Bridge & Iron Co.
Vice-Chairman—Dr. J. T. MacKenzie, Chief Metallurgist, American Cast Iron Pipe Co.
Secretary-Treas.—J. E. Durstine, Sales Manager, The Lincoln Electric Company.

Welding at the Railroad Exhibit

Members of the Society who studied our pictorial review of welding progress in the railroads in the May and June issues of the JOURNAL, will be interested to know that the applications of welding received consideration in the majority of exhibits at the Exposition. This varied all the way from an all-welded booth of the Aluminum Company to completely welded cars by several of the prominent manufacturers of railroad equipment.

SECTION ACTIVITIES

CLEVELAND

The following are the officers elected for the Cleveland Section for the coming year:

Chairman—E. R. Benedict, Engineer, Contract Welders, Inc., Cleveland
Vice-Chairman—Fred L. Plummer, Assoc. Prof. of Structural Engineering, Case School of Applied Science, Cleveland.
Secretary-Treas.—E.T. Scott, President, Cleveland School of Welding, Inc., Cleveland.

KANSAS CITY

The fourth regular monthly meeting of the Kansas City Section was held on June 21st at the Kansas City Power and Light Company. Mr. Leon C. Bibber, Welding Engineer of the Carnegie-Illinois Steel Co. addressed the meeting on "Welding Standards." An informal discussion followed Mr. Bibber's address.

MILWAUKEE

The Milwaukee Section announces the election of Mr. K. L. Hansen, of the Harnischfeger Corporation. He was Chairman of the Section at a meeting held on Thursday, May 27th. Mr. Harold Falk of the Falk Corporation was elected Vice-Chairman and Mr. J. J. Chyle of the A. O. Smith Corporation was elected to take over the duties of Secretary and Treasurer.

MONTANA

The Montana Section held their regular meeting June 2nd in the Administration Building at Fort Peck. A paper entitled "Arc Welding Power Supply," was presented by Roy L. Spaulding, Junior Engineer. This paper was followed by Mr. Peterson of the Government Laboratory who exhibited with the aid of a high power microscope, and microphotos, a piece of 0.90 high carbon steel that had been welded.

ST. LOUIS

The newly elected officers of the St. Louis Section for the fiscal year June 1, 1937 to June 1, 1938 are as follows:

Chairman—A. W. Harris
Vice-Chairman—F. J. Feldhaus
Secretary—C. W. Sammelman
Treasurer—N. F. Moss
Directors—W. E. Corby, F. C. Fantz, Lockwood Hill, B. H. Leonard, C. W. S. Sammelman and R. C. Thumser
Section Representative on Board of Directors—A. W. Harris

WESTERN NEW YORK

At the meeting of the Western New York Section held June 18th, the following officers were elected:

Chairman—H. J. Schleider
Vice-Chairman—Robert Siemer
Secretary-Treas.—F. O. Howard
Directors (2 years)—J. A. Fish and F. L. Rogers
Directors (1 year)—Charles S. Freeman and M. P. Korn

SAN FRANCISCO

At a meeting of the San Francisco Section held on May 21st the following nominees were elected:

Chairman—N. F. Ward, University of California
Vice-Chairman—Ted Rooney, Western Pipe & Steel Co.
Secretary—J. G. Bollinger, Air Reduction Sales Co.
Treasurer—H. W. Saunders, Air Reduction Sales Co.
Executive Committee—K. V. King, Standard Oil Co. of Calif. C. S. Smith, The Linde Air Products Co. E. L. Mathy, Victor Equipment Company

Come to Atlantic City and Meet the Welding Folks!

Indications are that this Annual Meeting will surpass all records in attendance, quality of papers and general value. Members of the Society who have attended these meetings in the past know the value of the discussions and the importance of getting acquainted and meeting other people in the welding field. New members are invited to take this opportunity of making themselves known. For the convenience of those who expect to attend, there is reproduced below a list of the officers of the Society who have this work in hand. Detailed arrangements for the convention will be under the guidance of the Philadelphia Section of the AMERICAN WELDING SOCIETY. A list of the committees of the Philadelphia Section that will supervise the work will be published in the next issue. The Baltimore Section will assist and the names of their representatives, on each committee will also be included.

Board of Directors

President, A. E. Gibson, Wellman Engineering Co., 7000 Central Ave., Cleveland, Ohio

Senior Vice-President, E. R. Fish, The Hartford Steam Boiler Insp & Ins. Co., Hartford, Conn.

Divisional Vice-Presidents:

New York and New England—J. H. Zimmerman, The Linde Air Products Co., Newark, N. J.
Middle Eastern Division—R. D. Thomas, Arcos, Inc., 401 N. Broad St., Philadelphia, Pa.
Middle Western Division—H. C. Boardman, Chicago Bridge & Iron Works, 1305 West 105th St., Chicago, Ill.
Pacific Coast—T. C. Smith, General Petroleum Corp., Los Angeles, Calif.
Southern—E. E. Dillman, Wyatt Metal & Boiler Works, Dallas, Texas

Section Representatives:

Boston, H. N. Ewertz, Austin Hastings Co., 226 Binney St., Cambridge, Mass.
Chicago, C. J. McGregor, American Steel & Wire Co., 208 So. La Salle Street, Chicago, Ill.
Cleveland, E. R. Benedict, Contract Welders, 2445 E. 79th Street, Cleveland, Ohio
Detroit, A. S. Douglass, Detroit Edison Co., 2000—2nd Ave., Detroit, Mich.
Kansas City, C. E. Woodman, Kansas City Bridge Co., 215 Pershing Road, Kansas City, Mo.
Los Angeles, Wayne A. Howard, General Petroleum Corp., 2525 E. 37th St., Los Angeles, Calif.
New York, S. S. Scott, U. S. Navy, Brooklyn, N. Y.
N. New York, L. R. Leveen, General Electric Co., Schenectady, N. Y.
Philadelphia, R. D. Thomas, Arcos, Inc., 401 N. Broad Street, Philadelphia, Pa.
Pittsburgh, W. W. Reddie, Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.
Portland, L. M. Pickett, Steel Tank & Pipe Co., P. O. Box 1899, Station F, Portland, Ore.
San Francisco, E. L. Mathy, Victor Equipment Co., 844 Folsom Street, San Francisco, Calif.
St. Louis, A. W. Harris, 2449 Milk Avenue, Alton, Ill.
Milwaukee, L. J. Larson, A. O. Smith Corporation, Milwaukee, Wis.
Maryland, Bela Ronay, Engr. & Experiment Station, U. S. Naval Academy, Annapolis, Md.
Montana, W. C. Anderson, 709 Musselshell St., Fort Peck, Mont.
Youngstown, G. A. Reinhardt, Youngstown Sheet & Tube Co., Youngstown, O.

Junior Past-Presidents:

D. S. Jacobus, The Babcock & Wilcox Company, 85 Liberty Street, New York, N. Y.
J. J. Crowe, Air Reduction Sales Company, 181 Pacific Avenue, Jersey City, N. J.

Directors-at-Large:

A. M. Candy, Hollup Corporation, 3357 West 47th Place, Chicago, Ill.
J. H. Deppeler, Metal & Thermit Corporation, 120 Broadway, New York, N. Y.
A. E. Gaynor, J. A. Roebling's Sons Company, 107 Liberty Street, New York, N. Y.
O. E. Hovey, Consulting Engineer, 71 Broadway, New York, N. Y.
L. S. Moisseiff, Consulting Engineer, 99 Wall Street, New York, N. Y.
C. A. Adams, E. G. Budd Manufacturing Co., 25th and Hunting Park Aves., Philadelphia, Pa.
H. M. Hobart, General Electric Company, Schenectady, N. Y.
F. T. Llewellyn, U. S. Steel Corporation, 71 Broadway, New York, N. Y.
H. L. R. Whitney, M. W. Kellogg Company, 225 Broadway, New York, N. Y.
D. S. Jacobus, The Babcock & Wilcox Company, 85 Liberty Street, New York, N. Y.
Ira T. Hook, American Brass Company, Ansonia, Conn.
G. A. Hughes, Truson Steel Company, Youngstown, Ohio
R. E. Kinkead, Consulting Engineer, 3441 Lee Road, Cleveland, Ohio
H. S. Smith, Union Carbide Company, 30 East 42nd Street, New York, N. Y.
Andrew Vogel, General Electric Company, Schenectady, N. Y.
J. J. Crowe, Air Reduction Sales Company, 181 Pacific Avenue, Jersey City, N. J.

Appointed Members:

Treasurer, C. A. McCune, Magnaflux Corporation, 25 West 43rd Street, New York, N. Y.
Managing Director, Warner S. Hays and Secretary, M. M. Kelly, AMERICAN WELDING SOCIETY 33 West 39th Street, New York, N. Y.

Technical Program Committee

Chairman, E. V. David, Air Reduction Sales Company, 60 East 42nd Street, New York, N. Y.
Secretary, W. Spraragen, AMERICAN WELDING SOCIETY, 33 West 39th Street, New York, N. Y.
G. N. Bull, The Lincoln Electric Company, 330 West 42nd Street, New York, N. Y.

J. J. Crowe, Air Reduction Sales Company, 181 Pacific Avenue, Jersey City, N. J.
R. S. Donald, Thomson Gibb Electric Welding Company, 50 Church Street, New York, N. Y.
T. C. Fetherston, The Linde Air Products Company, 205 East 42nd Street, New York, N. Y.
Charles Kandel, Craftsweld Equipment Company, 2727 Jackson Avenue, Long Island City, N. Y.
Milton Male, United States Steel Corporation, 71 Broadway, New York, N. Y.
C. W. Obert, Union Carbide Company, 30 East 42nd Street, New York, N. Y.
J. W. Sheffer, American Car and Foundry Company, 30 Church Street, New York, N. Y.
G. Van Alstyne, Air Reduction Sales Company, 60 East 42nd Street, New York, N. Y.
E. Vom Steeg, General Electric Company, 570 Lexington Avenue, New York, N. Y.
A. F. Keogh, Sound Welding, 905 East 134th Street, New York, N. Y.
C. A. McCune, Magnaflux Corporation, 25 West 43rd Street, New York, N. Y.
F. E. Rogers, Air Reduction Sales Company, 60 East 42nd Street, New York, N. Y.

Convention Committee

C. A. McCune, *General Chairman;* Magnaflux Corp., 25 West 43rd Street, New York, N. Y.
M. M. Kelly, *Secretary,* AMERICAN WELDING SOCIETY, 33 West 39th Street, New York, N. Y.
J. B. Tinnon, *Chairman,* Manufacturers Committee; Metal & Thermit Corp., 120 Broadway, New York, N. Y.
E. V. David, *Chairman,* Technical Program Committee; Air Reduction Sales Company, 60 East 42nd Street, New York, N. Y.
T. M. Jackson, *Chairman,* Philadelphia Section; Sun Shipbuilding & Dry Dock Co., Chester, Pa.
H. E. Hopkins, *Secretary,* Philadelphia Section; Arcos, Inc., 401 N. Broad Street, Philadelphia, Pa.

TENTATIVE PROGRAM EIGHTEENTH ANNUAL MEETING AND WELDING EXPOSITION OF THE AMERICAN WELDING SOCIETY

OCTOBER 18–22, 1937

ATLANTIC CITY, N. J.

Headquarters for Technical Sessions and Committee Meetings—Hotel Traymore

Exposition—Convention Hall

Monday, October 18th

Morning

9:30 A.M. Business Session.

President A. E. Gibson, *presiding*

Opening address by President.
Report on Welding Research Activities by C. A. Adams.
Tellers' Report on Election of Officers.
Award of Samuel Wylie Miller Memorial Medal.
Award of Lincoln Medal.
Progress Report of Managing Director.
Review of Committee and Section Activities by Chairmen.
Discussion.

Afternoon

2:00 P.M. Technical Session.

G. F. Jenks, *Chairman,* Col. Ord. Dept., U. S. Army.
E. Vom Steeg, *Vice-Chairman,* General Electric Company.

INDUSTRIAL RESEARCH

Weldability of Low Alloy Steels, by W. L. Warner, Watertown Arsenal.
Recent Progress in Welding of Copper Alloys, by D. K. Crampton and J. J. Vreeland, Chase Brass & Copper Company.
Survey of Low-Alloy Steels as to Weldability, by J. H. Critchett, Union Carbide & Carbon Res. Laboratories.
Physical Properties and Corrosion Resistance of Nickel-Iron Alloys Formed in the Welding of Nickel-Clad Steel, by J. H. Deppeler, W. G. Thiesinger and F. G. Flocke.
The Problem of Correlation of Radiographs and Mechanical Tests of Welds, by J. T. Norton, Massachusetts Institute of Technology.

Evening

6:30 P.M. Board of Directors' Meeting

Dinner followed by meeting.
Review of Society activities, appointment of committees and officers.
New Business.

Tuesday, October 19th

Morning

9:30 A.M. Technical Session.

Charles I. MacGuffie, *Chairman;* General Electric Company.
Otto H. Henry, *Vice-Chairman;* Polytechnic Institute of Brooklyn.

FUNDAMENTAL RESEARCH IN WELDING

A Study of Stress Relief in Metals by an X-Ray Method, by J. T. Norton, Massachusetts Institute of Technology.
Proximity Effect in Welding Problems, by E. Bennett, University of Wisconsin.
The Heat Effect in Welding—by W. H. Bruckner, U. S. Naval Research Laboratory.

Afternoon

Two Simultaneous Technical Sessions

FUNDAMENTAL RESEARCH IN WELDING

2:00 P.M. Technical Session

T. M. Jackson, *Chairman,* Sun Shipbuilding & Dry Dock Company.
J. H. Zimmerman, *Vice-Chairman,* The Linde Air Products Company.
Stresses in Fillet Welds When Subjected to Bending Action, by Cyril D. Jensen, Lehigh University.
Welding of Copper, by A. P. Young, Michigan College of Mining & Technology.
Static and Impact Tensile Properties of Stainless Steel Welds at Ordinary and Low Temperatures, by O. H. Henry, Polytechnic Institute of Brooklpn.
Effect of Welded Clip Angles on Beam-Column Connections, by Inge Lyse, Lehigh University.

High Speed Motion Pictures of Flame Cutting, by H. R. Bullock, Massachusetts Institute of Technology.

JOINT SESSION WITH AMERICAN SOCIETY OF MECHANICAL ENGINEERS

2:00 P.M. Technical Session

Resistance Welding Fabrication, by J. M. Cooper, General Electric Company.

Fusion Welded Fabrication, by H. N. Blackmon, Westinghouse Electric & Mfg. Co.

Evening

7:30 P.M. Conference and Meeting of Fundamental Research Committee.

H. M. Hobart, *Chairman*, General Electric Company.

This conference is scheduled for university research workers in the fundamentals of welding.

Wednesday, October 20th

Morning

9:30 A.M. Technical Session

H. C. Boardman, *Chairman*, Chicago Bridge & Iron Works.

E. V. David, *Vice-Chairman*, Air Reduction Sales Company.

FABRICATION

Carbon Arc Welding in Automotive Work, by William Richards, Chevrolet Motor Co.

Automatic Resistance Welding, by Harry Landstrom, Nash-Kelvinator Corp.

Arc Welding of Steel Mill Machinery, by E. E. Tross, Gen. Supt., United Engineering & Foundry Company.

Welding—An Aid in Dam Construction.

Afternoon

NO TECHNICAL SESSIONS ARE BEING SCHEDULED FOR WEDNESDAY AFTERNOON in order to provide members of the Society an opportunity to see the Metals Exposition. Several Committee meetings will, however, be held.

Thursday, October 21st

Morning

9:30 A.M. Technical Session.

Everett Chapman, *Chairman*, Lukenweld, Inc.

Milton Male, *Vice-Chairman*, U. S. Steel Corporation.

SYMPOSIUM ON ALLOY STEELS

Low Alloy Steels—G. S. Mikhalapov, Heintz Manufacturing Company.

High Alloy Steels—T. R. Lichtenwalter, and V. W. Whitmer, Republic Steel Corp.; W. B. Miller, Union Carbide & Carbon Res. Labs.; J. C. Holmberg, Struthers-Wells-Titusville Corp.; R. Vincent, President, Alloy Fabricators.

Afternoon

2:00 P.M. Technical Session.

W. M. Mitchell, *Chairman*, Carnegie-Illinois Steel Corp.

J. J. Crowe, *Vice-Chairman*, Air Reduction Sales Company.

SHIPBUILDING

Welding in Building Tanker Vessels, by T. M. Jackson, Sun Shipbuilding & Dry Dock Co.

Assembly Plant for the Welding of Barges, by Geo. F. Wolfe, Dravo Corporation.

Phases of Testing in the Welding of Naval Vessels, by Lieut. Commdr. W. P. Roop, U. S. Navy.

All-Welded Steel Tankers, by A. C. Leigh, The Ingalls Iron Works Co.

Friday, October 22nd

Morning

9:30 A.M. Technical Session

P. G. Lang, Jr., *Chairman*, The Baltimore and Ohio R. R. Company.

A. F. Davis, *Vice-Chairman*, The Lincoln Electric Company.

RAILROAD SESSION

Building Up Locomotive Drive Box, by I. T. Bennett, Revere Copper & Brass, Inc.

Machine Gas Cutting in Railroad Work, by H. Bass, New York Central Railroad.

Welding of Railroad Rolling Stock, by V. R. Willoughby, American Car and Foundry Co.

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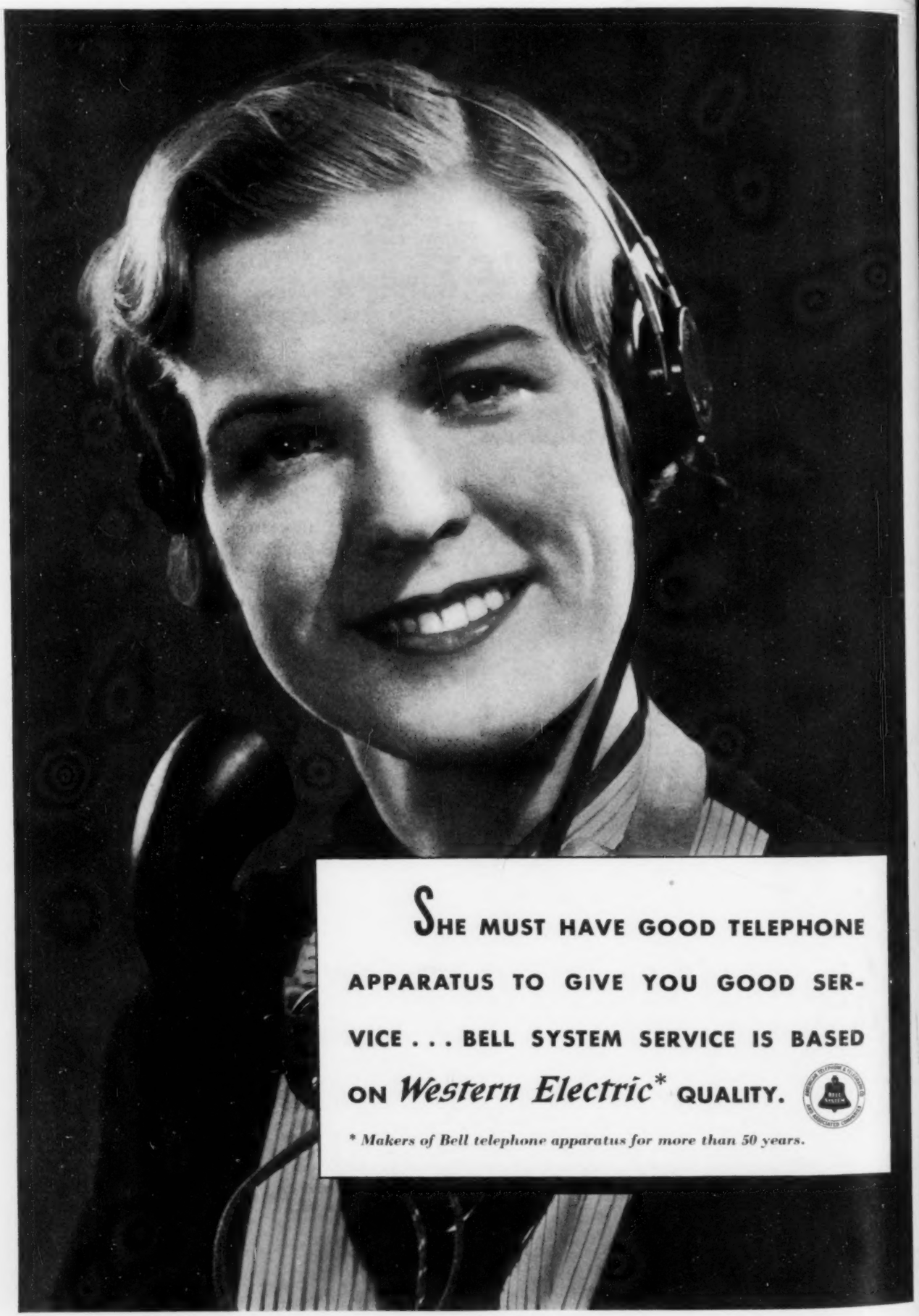
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